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OPTIMIZATION OF OFFICE PAPER RECOVERY SYSTEMS

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This study assesses source separation of paper as a viable resource recovery option in office buildings. Three basic approaches to office source separation are analyzed in terms of economics and performance based on their performance at 12 case study locations. The report gives an overview of source separation operations and solid waste management activities, and analyzes the major factors involved in implementing and running a source separation program. This is followed by an examination of program economics prior to and after implementation of the source separation subsystem using both the incremental and fully allocated approaches. This study concludes that source separation is practicable and economically viable, and that separation of high-grade white paper using the desk-top container approach is the most effective method.

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- National Bureau of Standards
- New Jersey Bell
- Oregon State Capitol
- Sentry Insurance Company
- University of Oregon
- Washington State Capitol
- Wells Fargo Bank
- Western Electric
- World Trade Center

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In addition we wish to express our sincere gratitude to Shade Information Systems, Inc. for coordinating case study visit arrangements with representative companies/agencies using the desk top system.

* One company requested total anonymity as a prerequisite for serving as a case study site. We respect their desires and acknowledge their participation in this study.

I

SUMMARY AND CONCLUSIONS

Office building solid waste generally contains mixed paper of varying grades and types which, by weight, accounts for 85 to 95 percent of the waste stream. In the past, the heterogeneous nature of this paper fraction has discouraged waste-paper dealers from regarding office buildings as a primary source of paper stock. Recyclable paper, however, can be separated from prohibitive contaminants such as carbon paper, bottles, cans, and organic materials at the point of waste generation. Such source separated quantities are then marketable.

The objective of this study was to assess source separation as a viable resource recovery option in office buildings. Three basic approaches to office building source separation were investigated at 12 case study locations:

Desk top - Each employee is provided with a small desk top container for isolation of source separated paper.

Dual basket - Each employee is provided with two "wastebaskets," one of which is designated for source separated paper.

Central container - Employees carry source separated paper to large containers conveniently placed throughout an office building.

In all instances, source separation of recyclable paper was performed by individual office workers on the accepted premise that employees will voluntarily contribute small amounts of time daily to a separation program without interruption of work routines or a reduction of overall office productivity.

Economics

The economics of all source separation programs studied were favorable, although variations were noted from program to program. Major independent variables included the method of separation, type of paper separated, building type and configuration, occupancy status (own/lease), and custodial arrangements (employee/contract). In general, however, the following economic conclusions can be made:

- Source separation is practicable and economically viable in office buildings. Overall solid waste management costs were effectively reduced by up to 59 percent; an average reduction of 12 percent was achieved.

- Startup costs averaged about 15 cents per employee and entailed expenditures for initial publicity/education, equipment, and, to a lesser extent, labor.

  - Publicity/education costs averaged 13 cents per employee, of which 3 cents were out-of-pocket expenditures for materials.

  - Incremental equipment costs were site specific, but averaged about 1 cent per employee.

  - Incremental labor costs at program inception were also site specific, depending on the degree to which paper collection could be absorbed in ongoing activities. Using monthly incremental labor costs as a proxy for startup costs, initial expenditures ranged from zero at seven case study sites to an average of 1 cent per employee per month at the five remaining sites.

- Program management was absorbed into existing workloads and entailed no out-of-pocket costs. Required administrative time at program inception ranged from 5 to 380 hours and averaged about 120 hours (equivalent to 3 minutes per employee), about 100 hours of which were absorbed by administrative personnel and about 20 hours by clerical employees. Ongoing program management required from 2 to 110 hours per month and averaged about 25, equally divided between administrative and clerical personnel.

Performance

- Initial and ongoing publicity/education is an absolute necessity of any source separation program to ensure employee participation and minimize contamination.

- Employee response to source separation was immediate and rapidly became habitual.

- Source separation programs attained high employee participation rates. Voluntary employee participation was as high as 95 percent and averaged 80 percent.

- Source separation can divert substantial portions of office building solid waste from disposal. Diverted quantities were as high as 78 percent and averaged 34 percent.

- Source separation programs were able to restrict contaminating materials to acceptable levels. Programs with the highest participation rate and the lowest contamination levels limited source separation to white high-grade paper (computer tab cards, computer printout, and white ledger).

Recommendations

Based on 12 case studies of alternative source separation and paper recovery schemes, the desk top method with exclusive separation of white high-grade paper is recommended for office building implementation. Compared with alternative approaches, the recommended method:

- Most effectively reduced solid waste management costs;

- Incurred the lowest startup costs;

- Achieved the highest employee response;

- Experienced the lowest level of contamination;

- Was most easily incorporated into normal office routines.

II

INTRODUCTION

Contemporary business and governmental practices require the collection, preservation, and dissemination of a truly staggering amount of information--generating a sea of paper. In recent years, this "information explosion" has increased the demand for high grade paper beyond domestic supply capacity.

In the flourishing economy of the 1960's, paper demand was met by large, small, and specialized paper mills. During 1969 and 1970, however, total output dropped; operating ratios fell to about 90 percent of capacity, followed by the demise of many small and/or specialized paper companies. Shortly afterwards, several inhibiting factors compounded the paper production crisis. Price controls in the United States caused a low rate of return on paper sold domestically. Low profits discouraged capital expansion; as paper demand climbed, many companies were caught with inadequate production capacity. Pollution abatement devices, necessary under federal and local laws, called for unplanned capital expenditures and increased operating costs. Shortages of raw materials and chemicals only increased the problems faced by American paper manufacturers. The energy crisis and a troubled economy created an uncertain situation in which manufacturers were reluctant to promise that future deliveries would be able to meet demands.[1,2]

Demand exceeds supply; the situation will become increasingly aggravated unless remedial conservation action is taken and paper control measures are adopted by business firms. Control could be achieved in one of two manners:

- Recycling of used paper products, and
- Source reduction.

This report focuses on the paper recycling measures that can be adopted in general office buildings.

Paper generated in office buildings primarily consists of four grades: mixed, newspaper, corrugated, and pulp substitutes/high grade deinking stock. This paper can comprise over 80 percent by weight of all office building solid waste. In view of the quantity generated, office buildings would appear to offer a primary source of reusable paper.

However, a 1970 survey of the paper stock industry by the National Association of Recycling Industries indicated that only one out of four paper stock dealers handled paper from office buildings.[3] Dealers were obviously interested in industries generating large volumes of homogeneous grades of relatively uncontaminated paper. The heterogeneous paper wastes which characterize office buildings cannot be directly reused in high grades manufacture without some degree of separation. If source separated into homogeneous grades, however, discarded paper would be marketable.

It was with respect to the unquantified aspects of office building source separation that the U.S. Environmental Protection Agency contracted with SCS Engineers to obtain detailed information on the performance and costs of such resource recovery programs. This report presents the results of 12 case studies performed on representative source separation programs throughout the nation. Since many variables between case study locations could not be controlled, the relationships developed and presented herein should be considered as best estimates from the empirical data available. In addition, the scope of work bounding the research performed did not encompass assessment of recycling mill capacity to absorb additional quantities of source separated office paper.

III

SOURCE SEPARATION OPERATIONS

Overview

In the course of this study, 12 source separation programs were assessed to obtain operational and cost information. Reasons and motivation for implementing source separation programs differed from site to site, as summarized in Tables 1 and 2. Program motivation was primarily from the management levels although employee impetus was also important at many of the sites visited. One program was initiated in response to a legislative mandate. Ecological concern was cited as the reason for starting a paper separation program at 92 percent of the case study locations. Waste disposal cost reduction and the related financial profit provided the second most prevalent motive for program initiation. A significant 42 percent of the case study sites used separation programs to create employment opportunities.

Table 3 provides descriptive information on the case study sites. The buildings studied were located throughout the nation and selected from three types of office buildings:

- Bank/Insurance Company buildings including two major banks and two major insurance companies.
- General Office buildings encompassing two state government complexes, two communication companies, and a federal government office complex.
- Multi-disciplined buildings including a manufacturing firm, a university, and a building housing tenants from a cross-section of business types.

The number of employees at case study locations ranged from 550 to 9,000 with a median employment of 1,800. The number of individual buildings at case study sites ranged from a single building to as many as 70.

Total solid waste generated at the case study sites ranged from 16 to 240 tons per month with a median generation of 62 tons per month.

All case study sites had conducted source separation programs for a minimum of one year. The average program had been in existence about three years; one program had been in operation for seven years.

TABLE 1

SOURCE OF MOTIVATION FOR IMPLEMENTING
PAPER SEPARATION PROGRAMS

Response	Source			
	Management Only	Employee/ Management	Employee Only	Legislative Mandate
Number	5	4	2	1
Percent	42	33	17	8

TABLE 2

REASONS FOR IMPLEMENTING
PAPER SEPARATION PROGRAMS

Response	Reason				
	Ecological	Reduce Disposal Costs	Financial Profit	Create Employment Opportunities	Legislative Mandate
Number*	11	7	7	5	1
Percent+	92	58	58	42	8

*12 total respondents (i.e., case study sites). Multiple reasons cause sum to exceed total number of respondents.
+Multiple responses cause sum to exceed 100 percent.

TABLE 3

CASE STUDY SITE DEMOGRAPHICS

General Building Information						Source Separation Approach			Paper Recovery						
										Grades Recovered					
										Computer		Ledger			
Building Type/ Number	Geographic Location	Number of Employees	Number of Buildings	Solid Waste Generation# (tons/mo)	Year of Program Initiation	Desk Top	Dual Basket	Central Container	Quantity Recovered# (tons/mo)	Tab Cards	Print-out	White	Colored+	News-paper	Corru-gated	Grade Mix
Bank/Insurance Company																
1	Northeast	9,000	3	240	1971			P	175	X			X			X
2	West	1,200	1	49	1971			P,S	9	X	*	X	X			
3	Midwest	1,700	4	17	1974	P			14	X	*	X				
4	West	1,180	1	59	1968			P,S	42	X	X	X	X		X	
General Office																
5	Rocky Mtn.	1,200	6	25	1971	P			7	X	*	X				
6	East	2,000	1	16	1974			P	7		*	X	X			
7	Northwest	7,500	18	118	1973		P		20							X
8	Northwest	6,040	16	134	1972		P		38	X						X
9	West	1,900	7	65	1972			P	11							X
Multi-disciplined																
10	Midwest	550	3	46	1974	P			3	X	*	X				
11	Northwest	1,200	70	89	1972		P		8	X				X		X
12	East	7,000	1	105	1974			P,S	19	X	X	X	X	X		

* Computer printout included in white ledger.
\+ Includes "mixed ledger" grade (white and colored ledger mixed together).
\# Rounded to nearest ton.

P: Primary source separation by office personnel.
S: Secondary sort conducted to separate by grades.

In addition to business type, source separation approach was an important criterion in the selection of case study sites. Three basic approaches to office building source separation were studied:

- Desk-Top* - Each employee working at a desk is provided with a small container (Figure 1) for the purpose of holding separated paper. Collection of the separated paper can be performed in several manners. The remaining solid waste is deposited in a wastebasket on the floor and collected for disposal in a conventional manner by custodians. Three desk-top programs were studied.

- Dual Basket - Each employee is provided with two baskets, one for recyclable paper and one for all other solid waste (Figure 2). The custodial staff separately or simultaneously collects the contents of each. Three dual basket programs were included in this analysis.

- Central Container - Desk employees separate paper and accumulate it in a receptacle of their own choice (desk drawer, one shelf of an "in-out" circulation basket, etc.). Accumulated paper is carried by the individual employee to a centrally located container (Figure 3). The central container approach is also used in departments where employees are not desk oriented and where large quantities of uncontaminated paper are generated (e.g., computer rooms, filing rooms). All other solid waste is placed in wastebaskets and handled conventionally. Six central container programs were selected for case study.

* As studied, the desk-top approach to source separation is offered by Shade Information Systems, Inc. Shade is a private firm primarily involved in the manufacture and sale of office paper (bonded ledger, computer printout, carbonless forms and bond made from recycled paper). Within the last 2 years, Shade has developed a complete desk-top office paper separation program offered to customers and other interested companies as an ecologically advantageous and cost-effective recycling system. The "Waste-Not© " program includes provision (at no direct charge) of all necessary desk-top containers, initial promotional/educational materials, and transportation of separated paper from office complex to paper stock dealer. The program, as operated, accepts white paper only (tab cards, printout, and ledger) and has been implemented in over 300 office buildings.

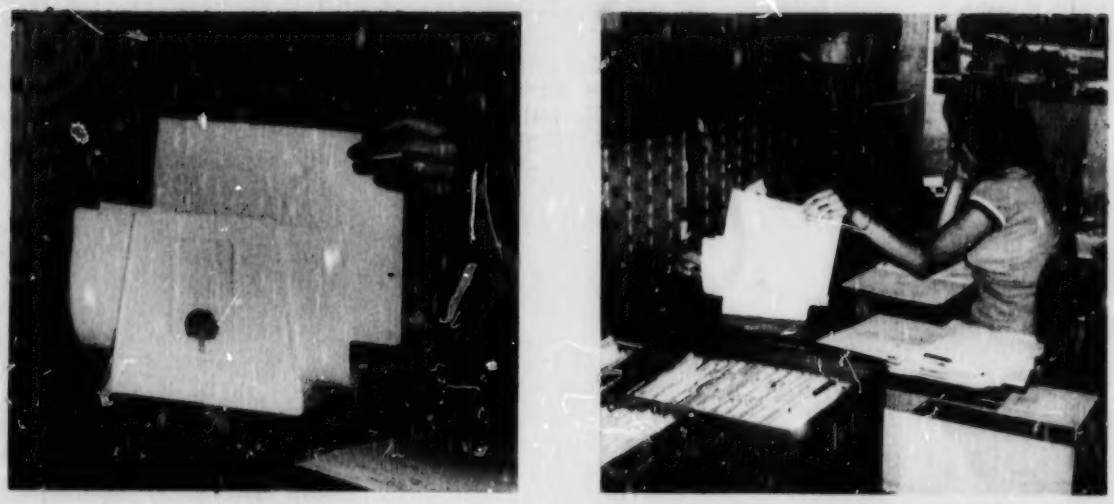

FIGURE 1. Typical Desk-Top Container

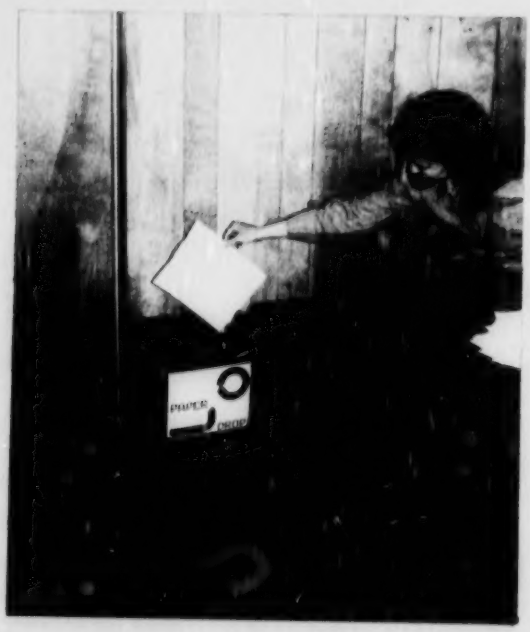

FIGURE 2. Typical Dual Basket Configuration

As indicated in Table 3, all 12 sites relied on employees to perform the initial source separation task: that is, to separate desirable paper from office waste. Three case study sites conducted secondary sorting (i.e., post-employee sorting) to remove residual contaminants and to separate by grade the paper recovered from initial employee separation.

Two case study sites (Buildings Nos. 1 and 4) restricted employees from eating lunch at their desks so that paper contaminants such as bottles, cans, organic lunch wastes, etc., did not enter desk waste baskets. Without these contaminants, both sites were able to fully or partially market unseparated office waste as a low grade paper mix. At all other case study sites, only those materials reclaimed through employee separation efforts were marketed.

The paper quantity and grade(s) separated at each case study location are shown in the last set of columns in Table 3. Computer tab cards having the highest market value were generally isolated from other wastepaper grades. Computer printout was generally included with white ledger unless a high degree of secondary sorting was performed. Similarly, colored ledger, unless secondarily sorted, was composed of a mixture of both white and colored ledger. Newspaper was separated at two case study locations, corrugated at one. At five locations, a mixed grade of paper was source separated. The cumulative quantities separated at each of the 12 case study locations ranged from 3 to 175 tons per month.

Solid Waste Management Activities

Each of the activities associated with managing solid waste from the point of generation through disposal is defined as a unit process. Unit processes associated with typical office building solid waste management are diagrammed in Figure 4. As seen, source separation is the only significant unit process variation between a system designed to collect and dispose all solid wastes generated and one which recovers recyclable paper from the waste stream. Thus, many of the unit processes associated with a source separation program can be integrated with ongoing waste management activities. With integration, however, paper contamination could be a problem if the system is not properly conceived and implemented. For example, receptacles on the floor (baskets, boxes, central containers) may have a "waste connotation," while elevated receptacles have a "recovery connotation." Container confusion could produce paper contamination.

Canvas Cart

Used Corrugated Box

Wheeled Container

Fiber Barrel

Figure 3. Typical Central Containers

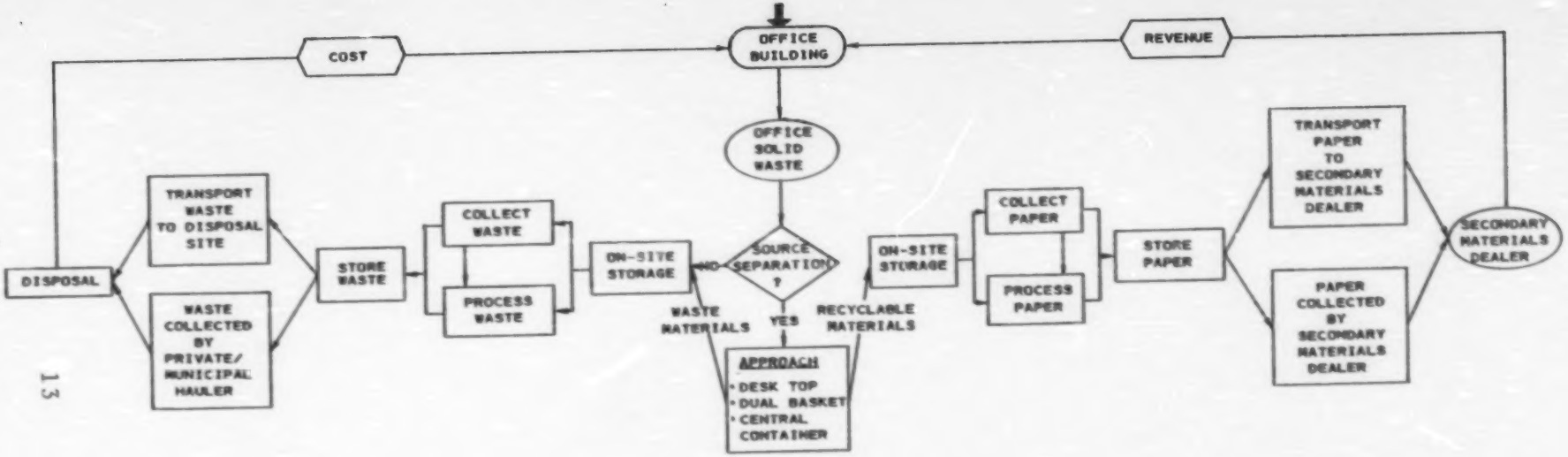

FIGURE 4. Solid Waste Management Activities With and Without Source Separation

Office Waste Characteristics

Certain parameters must be considered in the incorporation of a source separation subsystem. Solid waste characteristics such as generation rate and composition differ from location to location. Office buildings are no exception. Attempts were made to correlate waste generation rate with such variables as number of employees (aggregate and by administrative/clerical job categories), useable floor space, and paper generating facilities (print shop, reproduction, computer). Short of a multiple regression analysis which was beyond the scope of this study, the aggregate number of employees was determined to be that variable most highly correlated with office building waste generation. Table 4 presents the relationships developed by building type. As shown, bank/insurance company buildings had solid waste generation rates ranging from 0.90 to 4.49 lbs per employee per day and categorically averaged 2.31 lbs per employee per day. General office building employees generated from 0.72 to 3.14 lbs of solid waste per day, averaging 1.55 lbs daily. Source reduction efforts were conducted in conjunction with source separation at the two case study sites with the lowest generation rates:

- Building No. 3 (0.90 lbs per employee per day) reduced paper consumption/waste generation by using both sides of computer printout paper.
- Building No. 6 (0.72 lbs per employee per day) instituted a paper reduction/conservation program with the aid of a reproduction machine company.

The building types included in the multi-disciplined category were too diverse to develop meaningful generation estimates.

Waste composition also varies by business type. Table 5 presents the results of representative waste sampling conducted at three bank/insurance companies (Buildings Nos. 1, 2, and 3) and three general office buildings (Building No. 9 and references No. 4 and 5).* As shown, paper is the predominant waste; recyclable grades total 87 percent by weight in bank/insurance companies and 74 percent in general offices. In each instance, white high grades (tab cards, printout, and ledger) constitute the greatest portion of the recyclable paper. These grades command substantially higher market prices than colored ledger or lower grades such as newspaper, corrugated, and "mixed" (see Appendix A).

* Sampling was not conducted at multi-disciplined case study sites due to building type/solid waste diversity.

TABLE 4

EMPLOYEE SOLID WASTE GENERATION BY BUILDING TYPE

Building Type/ Number	Office Employees* (no.)	Building Solid Waste Generation (lbs/day)	Average Employee Generation Rate (lbs/employee/day)
Bank/Insurance			
1	9,000	21,820	2.42
2	990	4,450	4.49
3	1,700	1,540	0.90
4	2,200	5,360	2.44
Average	--	--	2.31
General Office			
5	1,040	2,270	2.18
6	2,000	1,450	0.72
7	7,440	10,730	1.44
8	6,040	14,730	2.44
9	1,880	5,910	3.14
Average	--	--	1.55
Multi-Disciplined			
10	550	4,180	7.60
11	1,200	8,090	6.74
12	7,000	9,540	1.36
Average	--	--	5.23

* Office workers only, does not include field personnel

TABLE 5

COMPOSITION OF OFFICE SOLID WASTE
BY BUILDING TYPE*

Material	Generation/Building Type (lbs/employee/day) Bank/Insurance Co. Range	Average	%	General Office Range	Average	%
Paper						
Computer Tab Cards	0.28-0.53	0.39	17	0.02-0.11	0.05	3
Computer Printout	0.60-0.74	0.70	30	T -0.17	0.11	7
White Ledger	0.67-0.74	0.70	30	0.31-0.62	0.51	33
Colored Ledger	0.05-0.16	0.12	5	0.05-0.19	0.09	6
Newspaper	T+-0.16	0.07	3	0.19-0.36	0.25	16
Corrugated	0.05-0.07	0.05	2	0.11-0.17	0.14	9
Other#	0.11-0.16	0.14	6	0.14-0.22	0.17	11
Garbage	T -0.07	0.02	1	0.05-0.12	0.09	6
Metal	0.02	0.02	1	0.02-0.05	0.03	2
Glass	T -0.02	0.02	1	T -0.06	0.03	2
Plastic	0.02-0.05	0.02	1	0.02-0.09	0.05	3
Textile	T -0.02	0.02	1	T	T	T
Wood	T -0.02	0.02	1	T	T	T
Miscellaneous	T -0.02	0.02	1	T -0.06	0.03	2
Total	---	2.31	100	---	1.55	100

* Based on representative solid waste sampling conducted at six buildings during study; does not include cafeteria waste

\+ Trace

\# Generally non-recyclable paper: carbon paper, wax coated or impregnated paper products, etc.

By building type, white high grades generated in bank/insurance companies ranged from 1.55 to 2.01 lbs per employee per day. Corresponding daily figures for general office buildings ranged from 0.33 to 0.90 lbs with an average of 0.67 lbs. Greater use of computers and the resulting generation of tab cards and printout accounts for the larger quantities estimated in bank and insurance complexes.

Source Separation

As practiced, initial separation of desirable paper from the waste stream does not require additional personnel. All 12 case study sites relied upon employees to perform this initial separation. It was assumed that employees would voluntarily contribute small amounts of time each day to paper separation without interruption of regular work routines or reduction of office productivity. Adequate initial and ongoing administration, including a publicity/education program, is required if positive employee response is to be gained ensuring enthusiastic participation and proper separation/preparation of paper.

Program Administration. Proper planning at program onset was universally stated as a necessary aspect of a successful source separation program. Initial efforts fell into two basic groups: (1) administrative tasks (e.g., assessing collection labor alternatives, designating container locations, negotiating paper purchase contracts, etc.); and (2) publicity/education. Initial administrative and clerical labor required to accomplish these efforts is delineated in Table 6 by building type and source separation approach. Due to case study site variables, each categorical tabulation contains a considerable range of requirements. With one exception (Building No. 11), all time was absorbed into existing workloads. Overall, initial required administrative and clerical time ranged from a low of 5 hrs to a high of 380 hrs, with a 12 case study average of 117 hrs. Computed in terms of time per employee, required time ranged from less than one minute to almost 13 minutes, averaging about 3 minutes per employee.

Ongoing administrative and clerical requirements are summarized in Table 7 with respect to building type and source separation approach. Ongoing program management required an average of 24 hrs per month. These labor requirements were also absorbed, again with the exception of Building No. 11. The minimal ongoing administrative requirements associated with the desk top (3 hrs per month) and central container (9 hrs per month) approaches are especially noteworthy. Larger ongoing administrative require-

TABLE 6

INITIAL ADMINISTRATIVE AND CLERICAL LABOR REQUIREMENTS[++]

-By Building Type-

Building Type/ Number	Personnel Requirements (hrs/mo) Pub./Ed. Adm.*	Pub./Ed. Clr.+	Admin. Adm.	Admin. Clr.	Total Adm.	Total Clr.
Bank/Insurance						
1	25	8	#	#	#	#
2	10	10	40	40	50	50
3	15	3	100	0	115	3
4	4	0	1	0	5	0
Average**	10	4	47	13	57	17
General Office						
5	80	3	165	0	245	3
6	40	2	4	6	44	8
7	20	10	40	10	60	20
8	20	10	350	0	370	10
9	11	28	50	2	61	30
Average	34	11	122	4	156	15
Multi-Disciplined						
10	4	2	13	0	17	2
11	40	20	40	20	80	40
12	40	0	35	0	75	0
Average	28	7	29	7	57	14
Overall Average**	26	8	76	7	102	15

-By Source Separation Approach-

Approach/ Building No.	Personnel Requirements (hrs/mo) Pub./Ed. Adm.	Pub./Ed. Clr.	Admin. Adm.	Admin. Clr.	Total Adm.	Total Clr.
Desk Top						
3	15	3	100	0	115	3
5	80	3	165	0	245	3
10	4	2	13	0	17	2
Average	33	3	93	0	126	3
Dual Basket						
7	20	10	40	10	60	20
8	20	10	350	0	370	10
11	40	20	40	20	80	40
Average	27	13	143	10	170	23
Central Container						
1	25	8	#	#	#	#
2	10	10	40	40	50	50
4	4	0	1	0	5	0
6	40	2	4	6	44	8
9	11	28	50	2	61	30
12	40	0	35	0	75	0
Average**	21	8	26	10	47	18
Overall Average**	26	8	76	7	102	15

* Administrative personnel
\+ Clerical personnel
\# No estimates available; personnel responsible for program initiation no longer employed
** Building No. 1 not included
\+\+ Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables

TABLE 7

ONGOING ADMINISTRATIVE AND CLERICAL LABOR REQUIREMENTS #

-By Building Type-

Building Type/ Number	Personnel Requirements (hrs/mo) Pub./Ed. Adm.*	Pub./Ed. Clr.+	Admin. Adm.	Admin. Clr.	Total Adm.	Total Clr.
Bank/Insurance						
1	5	0	5	0	10	0
2	10	10	0	0	10	10
3	1	1	1	1	2	2
4	1	1	1	1	2	2
Average	4	3	2	1	6	4
General Office						
5	1	1	1	0	2	1
6	2	0	2	0	4	0
7	8	3	28	13	36	16
8	0	0	26	52	26	52
9	5	5	3	1	8	6
Average	3	2	12	13	15	15
Multi-Disciplined						
10	1	0	1	0	2	0
11	40	40	20	10	60	50
12	1	0	1	0	2	0
Average	14	13	7	3	21	16
Overall Average	6	5	7	6	13	11

-By Source Separation Approach-

Approach/ Building No.	Personnel Requirements (hrs/mo) Pub./Ed. Adm.	Pub./Ed. Clr.	Admin. Adm.	Admin. Clr.	Total Adm.	Total Clr.
Desk Top						
3	1	1	1	1	2	2
5	1	1	1	0	2	1
10	1	0	1	0	2	0
Average	1	1	1	<1	2	1
Dual Basket						
7	8	3	28	13	36	16
8	0	0	26	52	26	52
11	40	40	20	10	60	50
Average	16	14	25	25	41	39
Central Container						
1	5	0	5	0	10	0
2	10	10	0	0	10	10
4	1	1	1	1	2	2
6	2	0	2	0	4	0
9	5	5	3	1	8	6
12	1	0	1	0	2	0
Average	4	3	2	<1	6	3
Overall Average	6	5	7	6	13	11

* Administrative personnel
\+ Clerical personnel
\# Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables

ments associated with the dual basket approach (80 hrs per month) may be more attributable to the multiple building aspect of the three case study sites and not solely to the approach (Buildings Nos. 7, 8, and 11 respectively include 18, 16, and 70 individual buildings).

Publicity/Education. A wide variety of initial publicity/education approaches were used at case study locations, including video-tape presentations, posters, memos, leaflets, company newsletters, etc. Program announcement and associated publicity outlining program goals and objectives preceded the implementation date by about a month. Publicity also included a description of the approach used and identified acceptable and unacceptable paper grades, a critical point for successful implementation.

Employee participation quickly became habitual and was easily incorporated into daily working habits. As a consequence, ongoing publicity/education generally documented program accomplishments and served to remind participants of the need to adhere to paper preparation requirements.

All 12 case study sites provided estimates of initial and ongoing publicity/education expenditures. Table 8 presents the aggregated administrative, clerical, and material costs for these efforts. Initial publicity/education costs for the 12 sites averaged 13 cents per employee, ranging from 3 to 72 cents. Out-of-pocket costs were limited to materials; administrative and clerical costs were absorbed in all instances. As a rule of thumb, material costs generally accounted for 20 to 30 percent of the expenditures listed in Table 8 for initial and ongoing efforts.

Ongoing publicity was basically limited to articles in company newsletters. Costs for ongoing efforts averaged 2 cents per employee per month; little variation in average expenditures per employee per month was reported.

Participation. Project coordinators at each case study location stated that employee response to source separation was immediate; among those employees who chose to participate in the programs, paper separation quickly became habitual. Table 9 presents employee participation rates by building type and source separation approach, as estimated by the respective project coordinators. With the noted exceptions, four out of five employees were estimated to participate continuously in the average paper recovery program.

TABLE 8

INITIAL AND ON-GOING PUBLICITY/EDUCATION COSTS*

Building Type/ Number	Publicity/Education Costs+		Total Employees (no.)	Cost per Employee	
	Initial ($)	On-Going ($/mo)		Initial ($)	On-Going ($/mo)
Bank/Insurance					
1	520	70	9,000	0.06	0.01
2	90	90	1,200	0.08	0.08
3	380	10	1,700	0.22	0.01
4	100	10	1,180	0.08	0.01
General Office					
5	860	10	1,200	0.72	0.01
6	1,090	20	2,000	0.05	0.01
7	230	80	7,500	0.03	0.01
8	260	0	6,040	0.04	-0-
9	1,030	160	1,900	0.54	0.08
Multi-Disciplined					
10	30	10	550	0.05	0.02
11	290	250	1,800	0.16	0.14
12	770	20	7,000	0.11	0.01
Overall Average	470	60	3,590	0.13	0.02

*Administrative, clerical and materials costs.
+Rounded to nearest $10.

TABLE 9

EMPLOYEE PARTICIPATION RATE#

- By Office Building Type -		- By Source Separation Approach -	
Building Type/Number	Participation Rate (%)	Approach/ Building Number	Participation Rate (%)
Bank/Insurance		Desk Top	
1	75	3	80
2	10*	5	95
3	80	10	95
4	63	Average	90
Average	73	Dual Basket	
General Office		7	67
5	95	8	70
6	93	11	80
7	67	Average	72
8	70	Central Container	
9	80	1	75
Average	81	2	10*
Multi-Disciplined		4	63
10	95	6	93
11	80	9	80
12	+	12	+
Average	88	Average	78
Overall Average	80	Overall Average	80

*Not included in averages. Program concentrated in areas with few employees/ heavy wastepaper generation; efforts to increase building-wide participation were being initiated at time of case study.

+Estimate of participation not available.

#Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables.

Although participation rates vary by building type, more significant variations appear between source separation approaches. The average desk top program attained a 90 percent participation rate. Central container and dual basket programs achieved significantly lower participation rates of 78 and 72 percent, respectively. Three possible explanations for this disparity are suggested:

- Publicity/education. Although a wide range of expenditures and other independent variables is represented, initial publicity/education cost per employee (from Table 8) appears to correlate with participation rate:

Approach	Participation Rate	Publicity Expenditures ($/Employee)
Desk top	90	0.37
Central container	78	0.15
Dual basket	72	0.05

- Level of separation required. The desk top programs studied accepted only white grades of paper which can be easily distinguished by an employee. Dual basket and central container programs generally sought to recover multiple grades and required employees to make additional distinctions among grades.

- Convenience. It is simply more convenient to place separated paper in a desk top container rather than in a basket on the floor or a central container.

Paper Preparation. Office building waste is chiefly composed of paper, 43 to 77 percent of which is high grade white paper, depending on business type (see Table 5). Given these facts, two options can be considered in planning a source separation program:

- Maximize paper recovery by separating all recyclable grades

- Maximize revenue by separating high grade paper only.

For each of these options, it must be determined whether the recovered paper is to be: (1) marketed in the employee-separated condition; or (2) sorted further and marketed by specific grade. As summarized below, seven case study sites sought to maximize recovery, thus minimizing paper

revenue; five, to selectively reduce disposable waste to maximize paper revenue. Nine of the 12 buildings studied marketed paper as separated by employees, with little or no secondary sorting; three sites performed secondary sorting to improve marketability.

Source Separation Objective	Number of Case Study Sites
Maximize recovery/Minimize paper revenue	
. Employee separated only	5
. Secondary sorting	2
Reduce disposal/Maximize paper revenue	
. Employee separated	4
. Secondary sorting	1

Once the grade of paper to be source separated has been selected, adherence to paper stock specifications is imperative for market acceptability. Specified contamination levels, expressed in terms of weight, generally range from 1 percent for high grades to 10 percent for low grades. Accordingly, employee education must emphasize the importance of proper separation/preparation to ensure that:

- A secondary sort is either not required or can be easily performed.
- Separated paper is not downgraded, resulting in a reduced revenue and making it necessary for the paper dealer to resort prior to mill acceptance.

Table 10 presents the estimated contamination level of source separated paper at the case study sites in terms of building type, approach, and type of paper separated. Desk top programs separating white paper only had an average post-employee contamination level of 3 percent, about one third that of the dual basket or central container programs, which averaged 9 and 8 percent, respectively. The relatively low contamination level of desk top programs may be attributed to a combination of two factors: (1) highest categorical expenditures for employee education; and (2) only easily identifiable white paper was source separated. A third, unquantifiable factor may also have contributed to the low contamination levels in desk top programs: placement of the container for separated paper on the desk (value connotation) rather than on the floor (waste connotation).

TABLE 10

CONTAMINATION LEVEL OF SOURCE SEPARATED PAPER*

-By Building Type-

Building Type/Number	Contamination Level (%)
Bank/Insurance	
1	21
2	10
3	5
4	1
Average	9
General Office	
5	2
6	1
7	10
8	2
9	3
Average	4
Multi-Disciplined	
10	1
11	15
12	5
Average	7
Overall Average	6

-By Source Separation Approach-

Approach/ Building Number	Contamination Level (%)
Desk Top	
3	5
5	2
10	1
Average	3
Dual Basket	
7	10
8	2
11	15
Average	9
Central Container	
1	21
2	10
4	1
6	1
9	3
12	5
Average	8
Overall Average	6

-By Paper Grade-

Paper Grade/ Building Number	Contamination Level (%)
White Only	
3	5
5	2
10	1
Average	3
White, Colored	
2	10
6	1
12	5
Average	5
White, Colored, Mixed	
1	21
4	1
Average	11
Mixed Only	
7	10
8	2
9	3
11	15
Average	8
Overall Average	6

* Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables

Case study sites using dual basket or central container approaches generally sought to maximize paper recovery by source separating and marketing a mixed grade or secondarily sorting into specific grades prior to marketing. Source separation of a mixed grade in Buildings Nos. 1, 2, 7, and 11 was apparently interpreted by employees as acceptability for all and any paper products; this resulted in post-employee contamination levels ranging from 10 to 21 percent. Secondary sorting was conducted at three of the four buildings to remove contaminating materials, for the most part newspaper and carbon paper. The five remaining dual basket/central container programs had contamination levels comparable to desk top programs, indicating operational viability of these methods. However, intensive employee education is essential when a mixture of paper grades is to be recovered, so that program participants recognize and remember unacceptable items.

Post-employee contamination levels achieved compared with paper stock dealer acceptance levels (see Appendix A) are summarized below on the basis of the paper grades separated at case study sites:

Grade	Acceptable Contamination (%)	Case Study Site Contamination (%)
White only	2	3
White, colored	2	8
Mixed	10	8

As shown, contaminants in white only programs exceeded the acceptable level. Acceptable white ledger requirements were achieved with minimal sorting, generally performed by collection personnel.* Contamination in mixed ledger (i.e., white, colored) programs was far in excess of accpetable levels; in mixed (i.e., high-low grade mix) programs, contamination levels fell within acceptable limits.

Diverted Disposal. The amount of paper diverted from total solid waste disposal averaged 34 percent by weight for the 12 sites studied. Individual and categorical diversion rates are cross-tabulated in Table 11 according to business type, source separation approach, and paper grade separated.

An average of 60 percent of office waste was diverted in bank/insurance company buildings through paper separation.

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* As practiced, contaminants were easily spotted by collection personnel when the desk top approach was used.

TABLE 11

WASTE QUANTITIES DIVERTED THROUGH SOURCE SEPARATION[++]

-By Building Type-

Building Type/Number	Diverted Disposal (%*)
Bank/Insurance	
1	73
2	19
3	78
4	70
Average	60
General Office	
5	29
6	42
7	17
8	28
9	17
Average	27
Multi-Disciplined	
10	7
11	9
12	18
Average	11
Overall Average	34

-By Source Separation Approach-

Approach/ Building Number	Diverted Disposal (%*)
Desk Top	
3	78
5	29
10	7
Average	38
Dual Basket	
7	17
8	28
11	9
Average	18
Central Container	
1	73
2	19
4	70
6	42
9	17
12	18
Average	40
Overall Average	34

-By Paper Grade-

Paper Grade/ Building Number	Diverted Disposal (%*)
White Only[+]	
3	78
5	29
10	7
Average	38
White, Colored[#]	
2	19
6	42
12	18
Average	26
White, Colored, Mixed[**]	
1	73
4	70
Average	72
Mixed Only	
7	17
8	28
9	17
11	9
Average	18
Overall Average	34

* Percent of total residual generation
\# Ledger
\+ Computer tab cards, printout, and ledger
** Multi-grade
++ Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables

General office buildings were able to divert an average of 27 percent of the waste stream; multi-disciplined buildings diverted an average of 11 percent. By using categorical waste sampling data from Table 5 as a proxy for maximum potential recovery, an effectiveness rating was calculated, averaging 75 percent for bank/insurance companies and 40 percent for general office buildings:*

Business Type	Paper in Waste (%)+ Available	Recovered	Recovery Effectiveness (%)
Bank/Insurance	80	60	75
General Office	68	27	40

The high effectiveness rating in bank/insurance companies is due in part to "natural" paper separation produced as a result of record retention policies, periodic file purging, and highly computerized business management operations. These functions generate large quantities of paper amenable to source separation.

Desk top and central container programs had average diversion factors of 38 and 40 percent, respectively. In terms of overall effectiveness, however, desk top programs would rate an edge, since similar quantities of paper are diverted from less available material. That is, the desk top programs sought only to recover white paper, which comprises a lower portion of the total solid waste stream than that available to central container programs recovering multiple grades. The diversion rate of 18 percent for dual basket programs was considerably lower than either alternative approach.

Assessing diverted disposal in terms of paper grade also yielded significant findings. At two case study sites (Buildings Nos. 1 and 4), recovery was maximized by implementing a dual recovery system. Central containers were used to recover mixed high grades. At the same time, employees were not allowed to eat at their desks. The resulting "desk waste" was entirely marketable as a low grade mix at Building No. 1 and partially marketable at Building No. 4.

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* Sampling data for multi-disciplined office buildings were unavailable. Bank/insurance company and general office building categories represent a variety of source separation approaches, custodial arrangements, recovered paper types, etc. It therefore appears that business type was the key variable explaining recovery effectiveness.

+ Recyclable portion only.

This dual system approach resulted in an average diversion rate of 72 percent, as indicated in the "white, colored, mixed" grade category on table 11. Of the 10 remaining locations which conducted skimming programs, the three programs recovering white paper only using the desk top approach were the most effective, diverting 38 percent of the total waste. The three programs recovering white and colored diverted an average of 26 percent of the total solid waste from disposal. The four programs designed to maximize recovery through separation of a low grade mix managed to divert only 18 percent.

Summary. On the basis of participation, contamination, and diverted disposal, and acknowledging independent variable uncertainties, the desk top approach was found to be decidedly preferable to either the dual basket or central container methods as a means of skimming recyclable paper from the waste stream. The total recovery approach used at two case study sites was highly effective. However, conditions enabling employee participation (adequate lounge and cafeteria space) and an available market for low grade mix are necessary for implementation.

On-Site Storage

Mixed Waste. Storage of mixed waste at an individual desk or in an area occupied by several non-desk oriented employees (computer room, file room, print shop) was comparable at all case study locations. Desk employees were each issued a 2-3 gal wastebasket to discard used materials. Areas such as computer rooms received one or more 20 to 50 gal containers (typically cardboard boxes), depending on the number of non-desk employees and the amount of waste generated.

Separated Paper. As previously defined, three methods of separated paper storage were assessed at the case study sites:

- The desk top approach entailed use of a small desk top container for storage of source separated paper. In addition, cardboard boxes were placed in areas with high paper generation (computer room, file room, print shop, reproduction area, etc.) for on-site storage.

- The dual basket approach provided a second wastebasket for storage of source separated paper. High generation areas received one or more 15-to-45 gal containers to store separated paper.

- The central container approach provided large containers (20 to 50 gal) throughout an office building for on-site storage.

On-Site Collection

Mixed Waste. Collection of mixed waste from office buildings was performed in a similar manner at all case study sites: custodians made daily rounds to collect refuse from each wastebasket in the building. Wheeled carts with drums, sacks, or bags attached were used to contain collected waste. When filled, the drum/sack/bag was wheeled to the nearest waste receptacle or processing area, the contents emptied or the full container discarded and replaced. The custodian then returned to his route. For high rise buildings, this sequence was modified to enable custodians to leave collected waste by the service elevator to be transported by a porter to the appropriate receiving area.

Time spent by custodians performing mixed waste collection activities prior to and after implementation of source separation programs is summarized below in terms of custodial time per day and custodial time per employee per month.

Mixed Waste Collection Time

	Range		Average	
	(hrs/ day)	(hrs/ employee/ mo)	(hrs/ day)	(hrs/ employee/ mo)
Prior to source separation	0.5-4.3	0.16-1.40	1.6	0.44
After source separation	0.5-3.2	0.12-1.05	1.4	0.35

The reduction in mixed waste collection time revealed in this summary can be directly attributed to paper separation. Smaller volumes of mixed waste require fewer custodial trips to the waste receiving area. If, however, waste and separated paper are collected simultaneously after implementation of a source separation program, the number of trips required should remain identical. Total collection time may possibly increase. Such an increase was noted at two of the four case study sites that implemented simultaneous collection systems:

Building Number	Source Separation Approach	On-Site Gathering Time (hrs/custodian/day) Prior to Implementation (Mixed Waste Only)	After Implementation (Mixed Waste and Separated Paper)
2	Central container	1.0	1.0
4	Central container	0.5	0.5
5	Desk top	1.0	1.1
7	Dual basket	1.4	1.7

Differences in participation rate, quantities collected, and building configuration make it impossible to determine if a particular source separation approach is more adaptable in terms of overall waste collection time. It is extremely important, however, that incremental times were absorbed into ongoing custodial operations, a key factor in optimizing source separation.

Separated Paper. Depending upon which source separation approach is used, varying amounts of labor and equipment are required to collect the separated paper and transport it to a central storage or processing area. Collection and transport of the paper was accomplished at case study sites using the approaches outlined below:

Desk Top Programs

- Custodians collected separated paper from desk tops and/or central containers while on routine waste collection rounds. The paper, after a quick review for contaminants, was either placed on a custodial cart shelf or in an extra sack or barrel carried on the cart. When the mixed waste container was filled, waste and recovered paper were simultaneously transported to a central storage area where the paper was placed in used corrugated boxes. Variations of this routine included (1) dropping full bags of paper in hallways for subsequent collection by another custodian with a large wheeled cart; and (2) dropping full bags of paper down a central waste chute to the storage area.

- Mail delivery personnel collected paper from the desks and reviewed it for contaminants while making multi-

daily deliveries. Collected paper was stored on the mail cart and transported back to the mail room where it was stacked in used corrugated boxes. Full boxes from the mail room and supplementary containers placed in high generation areas were transported by custodians to the central storage area.

- Part-time personnel were hired to perform the entire process: collecting paper from desk tops and central containers, reviewing it for contaminants, and transporting it to the central storage area.

Dual Basket Programs

- During normal daily waste collection, custodians emptied the contents of each basket into the appropriate sack or container on custodial carts. When the mixed waste container was filled, the cart was transported to the storage area. The separated paper container, whether or not it was full, was also exchanged for a new one at this time.

- Each participant was responsible for emptying the paper basket into one of many central containers, conveniently located throughout the facility. When full, central containers were transferred to a main storage location, emptied into larger storage containers, and returned to their original location.

Central Container Programs

- Custodians transported central containers to a main storage area and returned empty containers to replace those collected while performing routine waste handling duties. Rather than transferring the entire container, custodians sometimes "topped off" the mixed waste barrel with paper from a central container, leaving the paper at the appropriate storage area enroute to dump mixed trash. In either instance, collection was generally provided according to generation rates; containers accepting heavy loads were serviced daily, light generation areas being serviced less frequently.

Table 12 shows that seven of the case study sites were able to use existing personnel to collect paper; five programs integrated paper collection with custodial functions, while one used mail distribution personnel and another, general service personnel. Five programs were unable to absorb

TABLE 12

LABOR UTILIZATION FOR PAPER COLLECTION

- By Labor Category -

Labor Category	Labor Utilization (no. programs)		
	Total By Category	Existing Resources	Incremental Requirements
Custodial	8	5	3
General service	1	1	-
Mail distribution	1	1	-
Students	1	-	1
Rehabilitation	1	-	1
Total	12	7	5

- By Source Separation Approach -

Approach	Labor Utilization (no. programs)		
	Total By Approach	Existing Resources	Incremental Requirements
Desk Top	3	2	1
Dual Container	3	1	2
Central Container	6	4	2
Total	12	7	5

paper collection activities;* three of these required additional custodial labor, one program used part-time work-study students, and another used personnel from a local social rehabilitation program. Tabulation by source separation approach indicates that labor can be more easily absorbed in desk top and central container than in dual basket programs. Although additional personnel may not be needed, time requirements for collection of source separated paper may increase, as suggested by Table 13. Comparing categorical time requirements with diverted disposal rates also indicates that desk top and central container programs were more efficient than dual basket programs:

Approach	Collection Time (hr/employee/mo)	Diverted Disposal Rate (% of total waste)
Desk top	0.07	38
Dual basket	0.07	18
Central container	0.08	40

Processing

Mixed Waste. Mechanical processing of mixed wastes was performed at four case study locations. Banks (Buildings No. 2 and 4) and state government complexes (Buildings No. 7 and 8) shredded confidential material to destroy legibility. Shredding was not integrated within the routine waste management system. In fact, based on data from Building No. 8, shredded material was about three times less dense in a loose state than other paper waste and required correspondingly more time and space to handle.

Stationary compactors were used to densify mixed waste at Buildings No. 1, 10, and 12. For organizations generating large volumes of waste, this processing technique cuts down the need for frequent collection by private or municipal haulers.

At one bank (Building No. 4), a baler was used to reduce storage space requirements, necessitated by company policy of retaining office waste for ten days prior to disposal.

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* Contracted custodial service agreements required renegotiation to account for labor requirements associated with separated paper collection. Of the three case study sites with contractual service, one was able to circumvent incremental labor requirements by effectively using undertime of two general service employees; at the other two sites, the addiitonal labor was accepted as a condition for program implementation.

TABLE 13

TIME REQUIREMENTS FOR COLLECTION OF SOURCE SEPARATED PAPER

Approach/ Building Number	Collection Requirements (hr/employee/mo)		
	Time	Absorbed	Incremental
Desk Top			
3	0.08	x	
5	0.06	x	
10	0.08		x
Average	0.07	0.07	0.08
Dual Basket			
7	0.06	x	
8	0.06		x
11	0.09		x
Average	0.07	0.06	0.08
Central Container			
1	0.02	x	
2	0.11	x	
4	0.23	x	
6	0.02	x	
9	0.02		x
12	*		*
Average	0.08	0.10	0.02
Overall Average	0.08	0.08	0.06

*Not estimable.

At the end of this period, the bales were scanned for contaminants that would restrict recycling as a low grade mix. Eighty percent of the bales were determined to be overly contaminated and were subsequently disposed.

Separated Paper. Source separated paper was manually and/or mechanically processed at five case study sites.

As previously stated, nine of the twelve programs studied opted to market employee-separated paper with minimal or no secondary sorting. Significant post-employee sorting to improve marketability was, however, conducted at Buildings No. 2, 4, and 12. Each of the three buildings used the central container approach. The mixed grade recovered through source separation was again sorted by hand into specific grades. Sorting was performed by incrementally hired personnel. Data from Building No. 12 were not amenable to analysis; approximately 10 to 20 hours were required to produce one ton of sorted paper at the other two sites:

Building Number	Sorting Time (person-hrs/ month)	Sorted Paper (tons/month)	Time Per Ton (hrs)
2	129	6.1	21.1
4	352	35.9	9.8

Mechanical processing of separated paper by means of densification was performed at Buildings No. 1, 4, and 5. Buildings No. 1 and 4 both used central container programs to recover mixed high grades. As noted above, both buildings requested employees to refrain from disposing of paper contaminants such as organic wastes and bottles in desk waste baskets.* At Building No. 1, reduced disposal costs supplied employee incentives, induced by a local demand for mixed low grade used in the manufacture of roofing paper and wallboard. A stationary compactor was provided by a local paper dealer to densify "desk wastes."

Elimination of at least the organic fraction from desk refuse at Building No. 4 was necessitated by the ten-day retention of all office waste. A baler was used to densify desk waste for retention; 20 percent of the bales (125 lbs each) were sufficiently free of contamination to be marketed as mixed low grade.

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* Based on representative sampling conducted at Building No. 1, employees adhered to the request; contaminants were found to be only one percent by weight.

At Building No. 5, a baler was used to densify white ledger recovered using the desk top approach to facilitate storage. The agreement between Building No. 5 and the paper purchaser provided an economic penalty for transporting accumulated paper quantities of less than 5 tons. Purchase of a baler minimized storage space and handling requirements during the time required to accumulate the minimum tonnage.

Central Storage

Mixed Waste. A wide variety of central storage approaches were used at case study locations: compaction containers with from 10- to 42-cu yd capacities, roll-off containers with capacities ranging from 20- to 30-cu yd, bulk bins with capacities of 1.5- to 3-cu yd, and an open trash room. The amount of space required for mixed waste varied according to many factors, including waste generation rate, number of buildings/collection points in a complex, amount of paper separated, loose or densified waste storage. Comparisons between buildings, therefore, have little meaning.

Separated Paper. Availability of space to store paper is often critical to the successful implementation of a source separation program - especially when office building designers tend to minimize the importance of mixed waste storage requirements and rarely consider the need for separated paper storage.[6,7]

Central storage containers were provided by paper dealers at seven case study sites. Container types provided ranged from 30-gal drums to a 42-cu yd compaction container. Where buildings opted to market specific grades, individual containers were generally provided. In all seven instances, the containers were provided at no direct cost.

Until storage became a problem at Building No. 5 (at which time baling was initiated), all three desk top programs used old corrugated boxes to store recovered paper. The boxes were stacked and banded on pallets for shipment. This procedure also diverted a portion of corrugated waste from disposal. At the two remaining case study sites, central storage containers were purchased or custom built.

Table 14 summarizes central storage space requirements for mixed waste and separated paper. The only meaningful interpretation that can be derived from this data concerns the ratio of space required for separated paper to that needed for mixed waste. This ratio was equal or greater at over 80 percent of the locations studied. It is likely that this ratio reflects the makeshift methods often used to accommodate paper accumulations.

TABLE 14

CENTRAL STORAGE APPROACH AND SPACE REQUIREMENTS

Residual/ Storage Approach	Space Requirements/Building Number (square feet)											
	1	2	3	4	5	6	7	8	9	10	11	12
Mixed Waste												
Stationary Compactor	500						400		420	130		1,500
Roll-Off Container		600					1,600	240			200	
Bulk Bin			100	150	300							
Trash Room						250						
TOTAL	500	600	100	150	300	250	2,000	240	420	130	200	1,500
Separated Paper												
Stationary Compactor	500								420			
Roll-Off Container								430				480
Bulk Bin*	625	60		90	60			580			450	
Drums						200	2,700					
Palletized Boxes			400	60	410			50				
Open Area				1,650	150	40				470		
TOTAL	1,125	60	400	1,800	620	240	2,700	1,060	420	470	450	480
Paper Space: Waste Space	2:1	<1:1	4:1	12:1	2:1	1:1	1:1	4:1	1:1	4:1	2:1	<1:1

* Includes canvas gurneys/carts
\+ Rounded to nearest integer

Transporation

Mixed Waste. Buildings No. 7, 8, and 11 provided their own service for mixed waste collection and hauling. All other case study sites received contractual or municipal service. In either case, mixed waste was collected at regular intervals and transported to a local disposal site. Seven of the twelve case study sites reduced the number of bins required to store mixed waste and/or reduced collection frequency as a result of source separating paper.

Separated Paper. Separated paper was transported by the purchaser at each case study location. With the desk top approach, a service charge was levied for quantities under 5 tons at Buildings No. 3, 5, and 10. Otherwise, frequency of collection varied from daily to bi-weekly, depending upon agreements reached between the office building and the paper dealer.

IV

SOURCE SEPARATION ECONOMICS

Methodology

Solid waste management cost data were gathered at each case study site to reflect costs prior to and after implementation of the source separation subsystem. As defined and exemplified below, these data were analyzed according to two cost accounting methods:

- The incremental method, which attributes costs or savings to a source separation program only if such costs or savings exceeded or reduced the amounts budgeted for solid waste management prior to program implementation. For example, if paper collection requirements were absorbed within existing labor allocations, incremental costs were not attributed. Conversely, personnel specifically hired to collect/sort separated paper and/or incremental equipment purchases provided costs wholly attributable to the program.

- The fully allocated method, which attributes costs or savings to a source separation program on the basis of apportionment.* For example, collection of separated paper by specially hired personnel sometimes reduced the amount of custodial time spent collecting mixed waste. The fully allocated method would assign a cost to paper collection personnel and attribute a savings to reduced custodial time, even if overall budgeted costs remained unchanged.

The incremental cost approach was deemed by the research team and case study site personnel to be at once the most practicable and realistic indicator of expenses and/or savings accruable to a solid waste management system incorporating a source separation program. Therefore, source separation economics herein presented reflect this methodological approach.

Fully allocated costs, while valuable aids to illuminate such variables as labor commitments, often distort true

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* The source separation effort by office personnel was excepted from consideration. Time to place separated paper in the appropriate container was assumed to be no greater than if waste was discarded in a wastebasket.

costs.* Readers interested in the fully allocated costs at each case study site may refer to the report addendum for further discussion and individual estimates using this cost accounting procedure.

Startup Costs

Startup cost elements associated with source separation programs include administration, equipment, and labor.

Administration

As defined in Section III, initial program administration encompassed administrative and clerical efforts for planning and publicity/education. In general, the only out-of-pocket expenditures went for publicity/education materials, and averaged three to four cents per employee. Although absorbed, the importance of administrative planning cannot be underestimated. The average of three minutes per employee should be viewed as the minimum required to attain a viable program. A well conceived and well planned program will reduce ongoing administrative requirements.

Equipment

Incremental equipment and labor costs are summarized by source separation approach in Table 15.+ Although site specific as discussed below, initial out-of-pocket equipment expenses at the sites studied ranged from zero at four locations to $16,400 at Building No. 8. Excluding Building No. 8, which individually accounted for nearly half of the total equipment expenditures at all case study sites, the average program incurred initial equipment costs of about $1,300. Restated in terms of median employment, incremental equipment costs averaged about one cent per employee.

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* For example, at Building No. 8, two laborers were hired specifically to collect source separated paper. As a result, custodial time to collect mixed waste was estimated to have been reduced by one-half hour per custodian per day. The custodial staff size and corresponding budget, however, remained unchanged. Attributing a cost savings of one-half hour per day to each of the 197 custodians employed at Building No. 8 would not indicate true program costs or savings.

+ No trends were apparent when startup requirements were compared by type of building.

Desk top programs were best able to minimize incremental startup equipment requirements. All desk top containers were provided without direct cost by the paper purchaser. Used corrugated boxes were utilized to store separated paper at all sites. In addition, a baler and central paper storage containers were purchased at Building No. 5 to reduce the space required to store up to 5 tons of paper prior to market transport.

Dual basket programs generally incurred the expected equipment expenses for separated paper collection. At Building No. 7, significant outlays were necessary to modify custodial carts to accommodate separated paper collection. A half-ton van was needed at Building No. 8 to collect accumulated paper quantities. Building No. 11 acquired a van at no cost for similar purposes. Building No. 8 also spent substantial amounts for central containers and customized central storage bins.

Startup expenses for central container programs involved the purchase of the containers themselves. At Building No. 4, a baler was also purchased to reduce the volume of the office waste. At Building No. 12, modification of several custodial carts required a small expenditure.

Labor

Incremental labor expenses were site specific. As an indication of initial out-of-pocket costs, Table 15 shows the monthly cost for incrementally hired personnel. As shown, incremental labor costs at seven sites ranged from $86 to $2,811 per month. Due to the variety of incremental labor requirements, averages are without meaning.

Collection labor requirements were most easily absorbed in the desk top programs. Building No. 10 used two part-time work-study students to collect separated paper. Incremental collection personnel were required at two of the three dual basket programs where custodial workloads were unable to absorb a separate paper collection task. Building No. 8 hired two full-time laborers to collect separated paper from throughout the 16-building complex. Similarly, a full-time project coordinator was responsible for the collection of separated paper throughout the 70-building complex at Building No. 11. The existing custodial staff at Building No. 7, comprised of 18 individual buildings, was able to absorb the paper collection function.

Incremental labor was required at four of the six central container programs. At Building No. 2, part-time help was hired to sort separated paper into specific grades. At

TABLE 15

INCREMENTAL SOURCE SEPARATION
PROGRAM STARTUP COSTS
FOR EQUIPMENT AND LABOR

- By Source Separation Approach -

Approach/ Building No.	Equipment Costs ($)					Labor Costs ($/mo)*		
	On-Site Storage	Collection	Processing	Central Storage	Total	Collection	Sorting	Total
Desk Top								
3					0			0
5			2,000	280	2,280			0
10					0	X		86
Dual Basket								
7		1,125			1,125			0
8	4,200	500		11,700	16,400	X		2,811
11					0	X		745
Central Container								
1	3,600				3,600			0
2					0		X	515
4			3,310		3,310		X	1,032
6	2,040				2,040			0
9	1,196				1,196	X		200
12	480	310			790	X	X	1,067

* Monthly costs shown as proxy for initial out-of-pocket costs

Building No. 4, two full-time laborers were hired to sort paper. The custodial contract at Building No. 9 was increased by two person-hours per day to cover additional time spent to collect separated paper. Labor at Building No. 12 for paper collection and sorting was supplied from a social rehabilitation program.*

Operating Costs

Analysis of all operating costs affecting solid waste management (equipment, labor, administration, disposal, paper revenue) was performed before and after source separation implementation to assess program viability.

The site specific nature of incremental equipment and labor costs carried over into operating costs. The equipment costs shown in Table 15 were assumed to be depreciated on a straight-line basis over a five-year period. On these terms, the incremental equipment operating costs of source separation ranged from zero at four sites to almost $500 per month at Building No. 8. Again excluding Building No. 8 on the assumption that equipment expenditures were inordinately high at that site, incremental equipment operating cost for the eleven remaining programs ranged from zero to $60 per month, averaging about $20 per month.

Incremental labor operating costs were presented in Table 15 and discussed in the preceeding section.

Incremental administrative costs were limited to ongoing costs for publicity/education materials; administrative and clerical labor costs were absorbed into existing workloads.

Waste disposal cost reductions were also site specific. Seven sites were able to reduce the number and size of storage containers and/or cut back collection frequency. In such instances, a diverted disposal savings was realized. Disposal savings were not realized at five sites for one or more of the following reasons:

- Insignificant waste reduction.
- Local health regulations required a minimum collection frequency if putrescible organic wastes were included with other office refuse.

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* Building No. 12 paid one-third of the personnel cost; the remaining portion was paid through state and federal funds.

- At sites comprised of multiple buildings, standard-sized bins were required at each building to minimize custodial collection duties. Waste reduction at each building did not effect overall collection requirements.

Revenue from sales of source separated paper served to defray/cover incremental operating costs. Table 16 summarizes typical revenues received by each case study site for specific grades separated. With the exception of Building No. 9, all sites with computer facilities kept tab cards separate from other grades. Computer printout was generally included with white ledger (bond, reproduction paper, etc.) except at Buildings No. 4 and 12, where additional employees were hired to sort recovered paper into specific grades. The notable decline in low grade sales price in conjunction with the relative quantities generated (refer to Table 5) makes low grades questionable for economical recovery. The same consideration applies to colored ledger.

Program Economics

Analysis of collection and disposal costs before and after implementation of source separation programs revealed that solid waste management costs were effectively decreased at nine of the twelve case study sites. In terms of percent change, the net costs ranged from a decrease of 35 percent to an increase of 7 percent, with an overall average decrease of 12 percent. Categorical assessments are made below on the basis of building type, source separation approach, and grade(s) of paper marketed.

Office Building Type

Table 17 summarizes the impact of source separation on overall solid waste management costs in terms of building type. Incremental collection costs were generally highest at banks and insurance companies; however, the impact of source separation was usually greatest due to large volumes of readily separable high grade wastepaper generated at these facilities. Two interrelated factors affected program economics at Building No. 2: (1) source separation was implemented in a portion of the office complex only; (2) the cost for a part-time worker hired to sort paper exceeded disposal and revenue savings. Revenue and disposal savings exceeded incremental costs by 28 to 35 percent at each of the three remaining buildings.

Overall solid waste management costs were reduced by 7 to 25 percent at four of the five general office buildings.

TABLE 16

TYPICAL REVENUES RECEIVED FOR SOURCE SEPARATED OFFICE PAPER

	Sales Revenue ($/ton)									
	High Grades							Low Grades		
	Computer Paper				Ledger					
	Tab cards			Printout	White	Colored	Mixed	Newspaper	Corrugated	Mixed
	Manila	Colored	Mixed							
1			18				35			0*
2		45	70		36+	23				
3			70		50+					
4			70	60	40	30			1	2
5	165				60+					
6	110				65+	60				
7	120						30	10	20	
8	96						5			
9										
10	140				59+					10
11	120						30	10		
12	148	104		95	70	40		26		

* No collection cost in exchange for paper
\+ Computer printout included in white ledger

TABLE 17

IMPACT OF SOURCE SEPARATION ON OVERALL
OFFICE BUILDING SOLID WASTE MANAGEMENT COSTS**
-By Building Type-

Building Type/ Number	Solid Waste Management Cost ($/ton) Prior to Source Separation	After Source Separation	Incremental Cost Factors (% Change*) Net Effect	= Collection#	+ Disposal	+ Revenue
Bank/Insurance						
1	34	23	-32	+ 1	- 7	-26
2	61	64	+ 5	+23	- 6	-12
3	92	60	-35	+12	0	-47
4	53	38	-28	+46	-15	-59
Average Change	--	--	-22	+21	- 7	-36
General Office						
5	107	80	-25	+ 2	- 5	-22
6	315	294	- 7	+ 1	- 4	- 4
7	74	67	- 9	0	0	- 9
8	412	419	+ 2	+ 6	- 2	- 2
9	77	70	- 9	+ 5	-12	- 2
Average Change	--	--	-10	+ 2	- 4	- 8
Multi-Disciplined						
10	47	43	- 8	+ 4	0	-12
11	75	80	+ 7	+12	0	- 5
12	134	132	- 1	+ 8	0	- 9
Average Change	--	--	- 1	+ 8	0	- 9
Overall Average Change	--	--	-12	+10	- 4	-18

* Change as a percent of total solid waste management cost (per ton) prior to implementation of source separation.

\# "Collection" encompasses equipment and/or labor to store, collect, and/or process source separated paper.

** Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables.

Paper revenue (mixed grade) and diverted disposal savings were not sufficient to overcome incremental equipment and labor costs at Building No. 8, resulting in a two percent increase.

Source separation had the least effect on costs at multi-disciplined buildings. Two of the three programs achieved some cost reduction; at Building No. 11, however, the incremental expense of paper collection labor was not compensated for by revenues from the mixed grade that was marketed. Due to the relatively small quantities of solid waste diverted by the multi-disciplined buildings (average of 11 percent), none of these programs accrued disposal cost savings.

Source Separation Approach

The impact of source separation on overall solid waste management costs according to approach is presented in Table 18. As shown, the desk top programs effectively reduced solid waste management costs from 8 to 35 percent, with an average reduction of 23 percent. The desk top approach was the only system in which revenue alone exceeded incremental collection costs. That is, diverted disposal savings were not required for the program to be "profitable." This is an important consideration, especially for companies/agencies occupying leased buildings in which diverted disposal savings revert to the building owner.

Two of the three dual basket programs effectively increased overall solid waste management costs by 2 and 7 percent; in the third program, overall costs were reduced by 9 percent. At those buildings where costs increased (Buildings No. 8 and 11), incremental collection costs were not covered by marketing a mixed grade of paper. Conversely, Building No. 7 was able to market a mixed grade and reduce overall costs because all collection functions and costs were absorbed.

Overall, central container programs effectively reduced solid waste management costs by an average of 12 percent. Five of the six programs achieved cost reductions ranging from one to 32 percent; at Building No. 2, costs increased five percent, due to sorting costs which exceeded revenue and diverted disposal savings.

Paper Grade

Table 19 summarizes the economic impact of source separation in terms of paper grade(s) marketed. The two case

TABLE 18

IMPACT OF SOURCE SEPARATION ON OVERALL
OFFICE BUILDING SOLID WASTE MANAGEMENT COSTS **
-By Source Separation Approach-

Approach/ Building No.	Solid Waste Management Cost ($/ton) Prior to Source Separation	After Source Separation	Incremental Cost Factors (% Change*) Net Effect	= Collection#	+ Disposal	+ Revenue
Desk Top						
3	92	60	-35	+12	0	-47
5	107	80	-25	+ 2	- 5	-22
10	47	43	- 8	+ 4	0	-12
Average Change	--	--	-23	+ 6	- 2	-27
Dual Basket						
7	74	67	- 9	0	0	- 9
8	412	419	+ 2	+ 6	- 2	- 2
11	75	80	+ 7	+12	0	- 5
Average Change	--	--	0	+ 6	- 1	- 5
Central Container						
1	34	23	-32	+ 1	- 7	-26
2	61	64	+ 5	+23	- 6	-12
4	53	38	-28	+46	-15	-59
6	315	294	- 7	+ 1	- 4	- 4
9	77	70	- 9	+ 5	-12	- 2
12	134	132	- 1	+ 8	0	- 9
Average Change	--	--	-12	+14	- 8	-18
Overall Average Change	--	--	-12	+10	- 4	-18

* Change as a percent of total solid waste management cost (per ton) prior to implementation of source separation.

\# "Collection" encompasses equipment and/or labor to store, collect, and/or process source separated paper.

** Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables.

TABLE 19

IMPACT OF SOURCE SEPARATION ON OVERALL
OFFICE BUILDING SOLID WASTE MANAGEMENT COSTS**
-By Paper Grade-

Grades Marketed/ Building Number	Solid Waste Management Cost ($/ton) Prior to Source Separation	After Source Separation	Incremental Cost Factors (% Change*) Net Effect	= Collection#	+ Disposal	+ Revenue
White Only						
3	92	60	-35	+12	0	-47
5	107	80	-25	+ 2	- 5	-22
10	47	43	- 8	+ 4	0	-12
Average Change	--	--	-23	+ 6	- 2	-27
White, Colored						
2	61	64	+ 5	+23	- 6	-12
6	315	294	- 7	+ 1	- 4	- 4
12	134	132	- 1	+ 8	0	- 9
Average Change	--	--	- 1	+11	- 3	- 9
White, Colored, Mixed						
1	34	23	-32	+ 1	- 7	-26
4	53	28	-28	+46	-15	-59
Average Change	--	--	-30	+23	-11	-42
Mixed Only						
7	74	67	- 9	0	0	- 9
8	412	419	+ 2	+ 6	- 2	- 2
9	77	70	- 9	+ 5	-12	- 2
11	75	80	+ 7	+12	0	- 5
Average Change	--	--	- 2	+ 5	- 3	- 4
Overall Average Change	--	--	-12	+10	- 4	-18

* Change as a percent of total solid waste management cost (per ton) prior to implementation of source separation.

"Collection" encompasses equipment and/or labor to store, collect, and/or process source separated paper.

** Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables.

study sites in the "white, colored, mixed" category each source separated high grade mixes, also marketing unseparated "desk waste" as a low grade mix. As mentioned above, waste contaminant control was accomplished by prohibiting employees from eating at their desks. This systemized approach reduced solid waste management costs by an average of 30 percent. Moreover, at Building No. 4, revenues from high grade separation exceeded the cost of two full-time sorters.

Programs skimming white paper only (all desk top) reduced costs from 8 to 35 percent, with an average reduction of 23 percent.

As a category, "white and colored" programs only marginally lowered solid waste management costs. Building No. 6 achieved a seven percent cost reduction by marketing white and colored paper in the employee-separated condition. Both of the other programs in this category sorted employee-separated paper into specific grades. Building No. 2 was unable to recover the sorting cost from sales revenues. At Building No. 12, a marginal reduction was achieved; however, only one-third of sorting personnel received wages, others being paid through a social rehabilitation program.

Sales of the "mixed only" grade provided the lowest revenue of any category. Buildings No. 8 and 11 were unable to recover the cost of supplemental paper collection personnel hired on a full-time basis. At Building No. 7, where the paper collection function was absorbed, and Building No. 9, which accepted a minor contract increase for paper collection, a source separation program was implemented while achieving overall cost reductions of seven and nine percent, respectively.

V

OPTIMIZATION ANALYSIS

Case study analyses indicate that source separation in office buildings is economically viable. As noted throughout this report, however, implementation approaches, personnel and equipment requirements, and paper market values varied from site to site. Therefore, an analysis to assess the optimal impact of source separation on overall solid waste management costs has been developed for a hypothetical general office building. This analysis was constructed using relevant data and/or inferences from the case study sites and assumes observed practices and operations to be typical. Comparisons were made of four alternative source separation schemes:

- Scheme 1: Source separation of white paper grades using three alternative approaches: desk top, dual basket, and central container. In each instance, computer tab cards were assumed to be manila and to be kept separate from computer printout and white ledger; the latter two grades were jointly marketed as white ledger.

- Scheme 2: Source separation of mixed high grade using the optimum approach determined from the Scheme 1 analysis. Computer tab cards were assumed to be independently separated.

- Scheme 3: Source separation of mixed low grade using the optimum approach determined from the Scheme 1 analysis. Computer cards were assumed to be independently separated.

- Scheme 4: Source separation of all recyclable paper (i.e., mixed low grade) using the optimum approach determined from the Scheme 1 analysis, with secondary sorting into specific grades for marketing. Computer tab cards were assumed to be independently separated.

Data Development

Evaluation of the alternative source separation schemes entailed the estimation of waste generation and composition

and evaluation of five cost elements: labor, equipment, overhead, disposal, and savings.

Waste Generation/Composition

The hypothetical general office building analyzed was assumed to house 1,800 employees (the median employment figure at the case study sites). Total solid waste generation for this building was estimated at 30 tons per month, based on the average general office building generation rate shown in Table 4.

The hypothetical waste composition for a general office building was derived from Table 5. The recoverable portion of each paper type was adjusted on the basis of the average employee participation rate for alternative source separation approaches.* Available and adjusted quantities are shown below:

Paper Type	Paper Availability (tons/mo)	Recoverable Portion (tons/mo)		
		Desk Top	Dual Basket	Central Container
Computer tab cards	1.0	0.9	0.9	0.9
Computer printout	2.1	1.9	1.5	1.6
White ledger	9.9	8.9	7.1	7.7
Colored ledger	1.8	1.6	1.3	1.4
Corrugated	2.7	2.4	1.9	2.1
Newspaper	4.9	4.4	3.5	3.8

Labor

Custodial labor was used on a daily basis to collect and transport discarded office waste to a central storage location. In the hypothetical building, 18 custodians were assumed to have been required. This figure was based on the median case study ratio of one custodian to each 100 employees prior to source separation implementation. Again based on case study data, custodians were assumed to have spent 1.6 hours per day performing solid waste-related activities. Custodian wages averaged about five dollars per hour, including fringe benefits.

Labor to collect source separated paper was absorbed at some case study sites, incremental at others, and varied by separation approach. Incremental paper collection tasks

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* Desk top, 90 percent participation; dual basket, 72 percent; and central container, 78 percent.

were assumed to have been conducted by custodians at the following rates:

Source Separation Approach	Incremental Paper Collection Requirements (hours per day)
Desk top	0.1
Dual basket	0.9
Central container	0.1

Sorting mixed grades of source separated paper into specific grades at the case study sites typically required 10 hours per ton of sorted paper. Sorters received burdened wages of about four dollars per hour.

Equipment

Based on a five-year straight line depreciation, the average cost for equipment such as wastebaskets, custodial carts, plastic bags, etc., averaged 10 cents per employee per month, or $180 per month for the hypothetical building. Incremental costs for equipment required to implement a source separation program varied by approach. For example, desk top containers were assumed to be supplied at no direct cost; dual basket programs generally entailed custodial cart modification costs and/or costs for containers; central container programs generally required purchase of the central containers themselves. Assuming processing, i.e., baling of separated paper was not to be performed, the average incremental equipment costs are summarized below:

Source Separation Approach	Incremental Equipment Cost ($/mo)
Desk top	2
Dual basket	32
Central container	21

Overhead

Overhead expenses for administration, building, and land were assumed to be five percent of equipment and labor costs.

Disposal

Solid waste disposal costs averaged $27 per ton at the case study sites.

Savings

Solid waste management cost savings realized through source separation can accrue as a result of diverted disposal and/or revenue from the sale of separated paper.

Disposal Savings. Disposal savings are generally not reduced in direct proportion to the quantity of waste diverted.* For example, the amount of paper diverted from disposal averaged 34 percent by weight at the case study sites, while disposal costs were reduced by an overall average of 18 percent. In other words, monetary savings averaged about half that of the disposed quantity reduction when both factors are expressed as percentages. This factor was used as a proxy for diverted disposal savings in the optimization analysis.

Revenue. The following paper stock prices typify prevailing markets and were used in the assessment:

Paper Grade	Market Price+ ($ per ton)
Computer tab cards	100
Computer printout	60
White ledger	50
Colored ledger	25
Corrugated	10
Newspaper	10
Mixed low grade	5

Optimization Analysis Results

Table 20 summarizes the analysis of the alternative approach/schemes.**

Optimum Approach

Each of the approaches analyzed in Scheme 1 effectively lowered overall solid waste management costs. The desk top

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* If the building is rented or leased, diverted disposal savings are not likely to be gained by the occupant, as would be the case if the occupant was also the building owner. For the purposes of this analysis, the hypothetical building was assumed to be owned by the occupant, as was the case at 10 of the 12 sites studied.

+ Prices estimated assume that the dealer provides the necessary central storage containers and transportation.

**Detailed figures supporting Table 20 appear in Appendix B.

TABLE 20

COST ANALYSIS OF ALTERNATIVE
SOURCE SEPARATION APPROACHES/SCHEMES

-Hypothetical General Office Building-

Contributing Factors	Solid Waste Management Costs ($/Month)						
	Prior to Source Separation	After Source Separation/Scheme					
		1			2	3	4
		Desk Top	Dual Basket	Central Container	Desk Top	Desk Top	Desk Top
Labor	3,168	3,179	3,267	3,179	3,179	3,179	4,039
Equipment	180	182	212	201	182	182	182
Overhead	167	168	174	168	168	168	211
Disposal	810	652	682	672	630	539	539
Paper Revenue	--	(630)	(520)	(555)	(400)	(186)	(738)
Net Solid Waste Management Costs	4,649	3,570	3,815	3,665	3,759	3,882	4,233
Solid Waste Generation (tons/mo)*	30	30	30	30	30	30	30
Net Cost per ton ($/ton)	155	119	127	122	125	129	141

* Total generation held constant for equitable comparison.

approach proved to be more economical than either the dual basket or central container approaches:

Alternative Source Separation Approach	Collection and Disposal Cost		
	Prior to Implementation of Source Separation ($/ton)	After Implementation of Source Separation ($/ton)	(% change)
Desk top	155	119	-23
Dual basket	155	127	-18
Central container	155	122	-21

Optimum Scheme

Using the desk top approach, each of the four separation schemes effectively reduced overall solid waste management costs in the analysis. Separation of white high grade paper, however, proved to be more economical than separation of either a high or low grade mix, with or without secondary sorting:

Alternative Source Separation Scheme	Collection and Disposal Cost		
	Prior to Implementation of Source Separation ($/ton)	After Implementation of Source Separation ($/ton)	(% change)
1 (White high-grade only)	155	119	-23
2 (Mixed high-grade only)	155	125	-19
3 (Mixed low-grade)	155	129	-17
4 (Mixed low-grade/ sort)	155	141	-9

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APPENDICES

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APPENDIX A

PAPER STOCK DEFINITIONS/HISTORIC PRICES

Introduction

Price information for five paper stock grades typically found in office buildings was obtained from Official Board Markets for the period encompassing 1970 through 1975:

1. Manila Tab Cards
2. Sorted White Ledger
3. No. 1 News
4. Corrugated Containers
5. No. 1 Mixed

Paper stock prices are given per short ton board mill prices, F.O.B. trucks, cars at dealers' or producers' plant exclusive of delivery, premium or distress lots, special packing, or other special charges. Grades are defined according to Paper Stock Standards and Practices, Circular PS-74, as published by the Paper Stock Institute of America, National Association of Recycling Industries, Inc.

Four geographical areas were selected to represent a cross-section of the nation and to plot historical price ranges:

Geographical Area	Representative Market
East	New York
Mid-west	Chicago
South	South*
West	Los Angeles

Manila Tab Cards

Definition: Manila tabulating cards consist of printed manila-colored cards, predominantely sulphite or sulphate, which have been manufactured for use in tabulating machines. This grade may contain manila-colored tabulating cards with tinted margins.

* Official Board Market listing.

Acceptable Contamination Level:

Prohibitive materials[+] - none permitted

Total outthrows[#] - may not exceed 1%

Price History: Table A-1 presents Manila Tab Card price fluctuations from 1970 through 1975. Prices remained relatively stable at $75 to $95 per ton until 1973 when the market rose sharply, peaking in mid-1974 at $200 to $250 per ton. By early 1975 prices had fallen to $125 to $150 per ton. At year end, manila tab card prices had again risen to $170 to $190, depending on geographical area.

Sorted White Ledger

Definition: No. 1 sorted white ledger consists of printed on unprinted sheets, shavings, and cuttings of white sulphate ledger, bond, writing, and other papers which have similar fibre and filler content. This grade must be free of treated, coated, padded, or heavily printed stock (typical examples of acceptable office paper include letterheads, including tissue copies; Xerox or IBM copies; business forms; stationery; and typing paper. Higher grades, such as manila tab cards and computer print-out, may also be included).

Acceptable Contamination Level:

Prohibitive materials: none permitted

Total outthrows: may not exceed 2%

[+] Prohibitive materials: (a) Any materials which by their presence in a packing of paper stock, in excess of the amount allowed, will make the packing unusable as the grade specified.

[#] Outthrows: Outthrows are understood to be all papers so manufactured or treated or are in such form as to be unsuitable for consumption as the grade specified.

Price History: Table A-2 summarizes sorted white ledger price history from 1970 through 1975. From 1970 through 1972 sorted white ledger prices remained constant at $35 to $50 per ton. Prices began rising in early 1973 and peaked in 1974 at a range of $100 to $160 per ton. Peak prices generally held for about eight months, then declined to the present level of $80 to $85 per ton, $35 to $50 per ton higher than 1970 prices.

No. 1 News

Definition: Consists of baled newspapers containing less than 5% of other wastepapers.

Acceptable Contamination Level:

Prohibitive materials - may not exceed 1/2 of 1%

Total outthrows - may not exceed 2%

Price History: As shown in Table A-3, prices for No. 1 news generally oscillated between $18 and $22 per ton from 1970 to mid-1973. Prices rose sharply during the following year, peaking at a price range of $38 to $60 per ton. From peak prices, the No. 1 news market plummeted and bottomed out at a low of $5 per ton. Late 1975 market prices have rebounded to 1970 price levels.

Corrugated Containers

Definition: Consists of baled corrugated containers with linings of either jute or kraft.

Acceptable Contamination Level:

Prohibitive materials - may not exceed 1%

Total outthrows - may not exceed 5%

Price History: Table A-4 shows the corrugated container price history from 1970 through 1975. Prices generally ranged from $20 to $25 per ton from 1970 to 1973, at which time prices rose, ranging from $46 to $60 per

ton by early 1974. Thereafter, prices fell to historic lows during the period studied, ranging from $8 to $25 per ton.

No. 1 Mixed

Definition: No. 1 mixed consists of a baled mixture of various qualities of paper containing less than 25% of groundwood stock, coated or uncoated.

Acceptable Contamination Level:

Prohibitive materials - may not exceed 1%

Total outthrows - may not exceed 5%

Price History: No. 1 mixed historic prices from 1970 through 1975 are presented in Table A-5. With the exception of a price dip in 1971, No. 1 mixed had market values ranging from $10 to $18 per ton from 1970 to mid-1973. Prices rose for a ten month period and peaked in early 1974 at a range of $18 to $46 per ton, whereupon values subsided to lows paralleling 1971. Late 1975 prices ranged from $5 to $18.

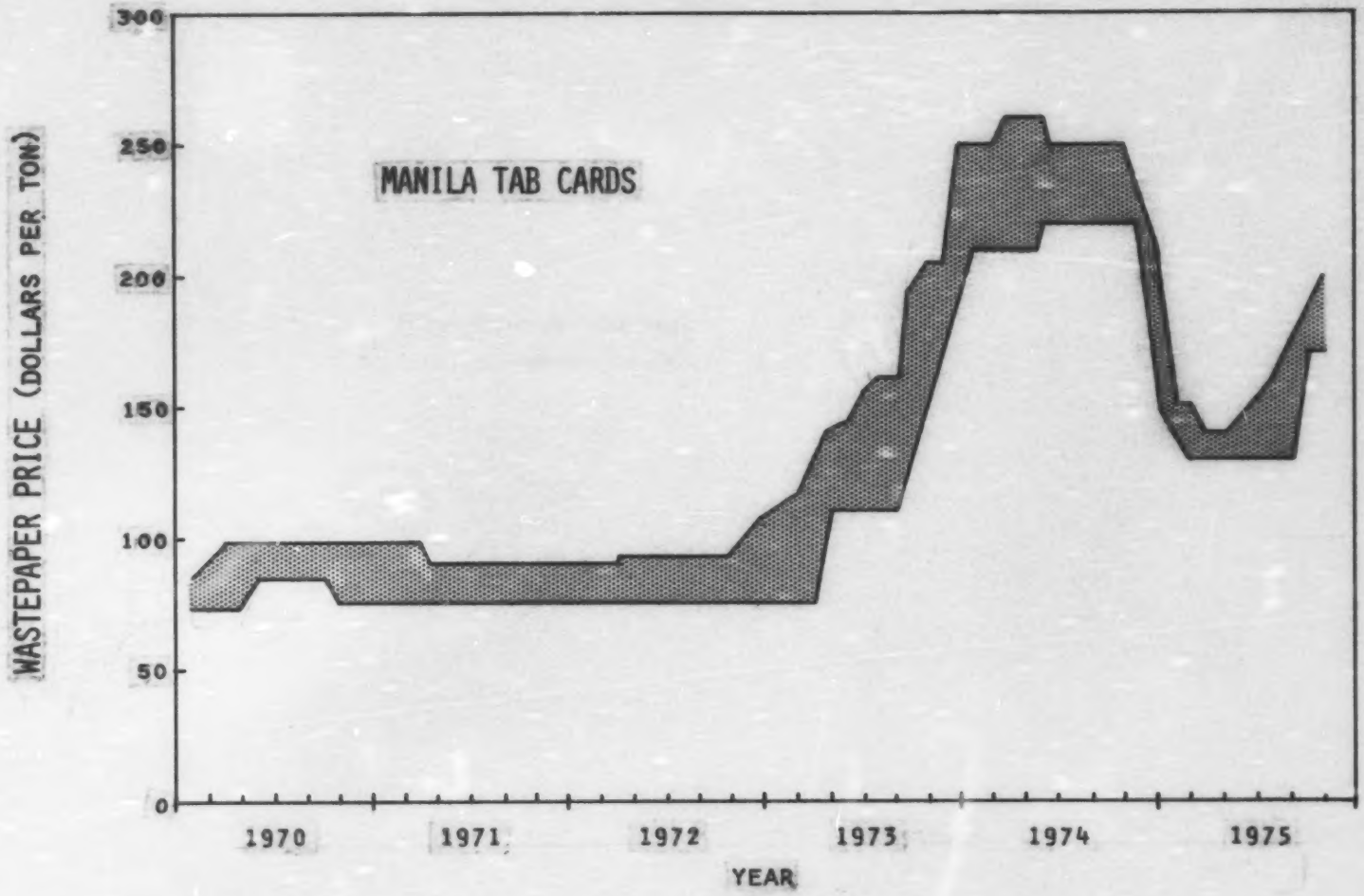

FIGURE A-1

HISTORICAL MANILA TAB CARD PRICES

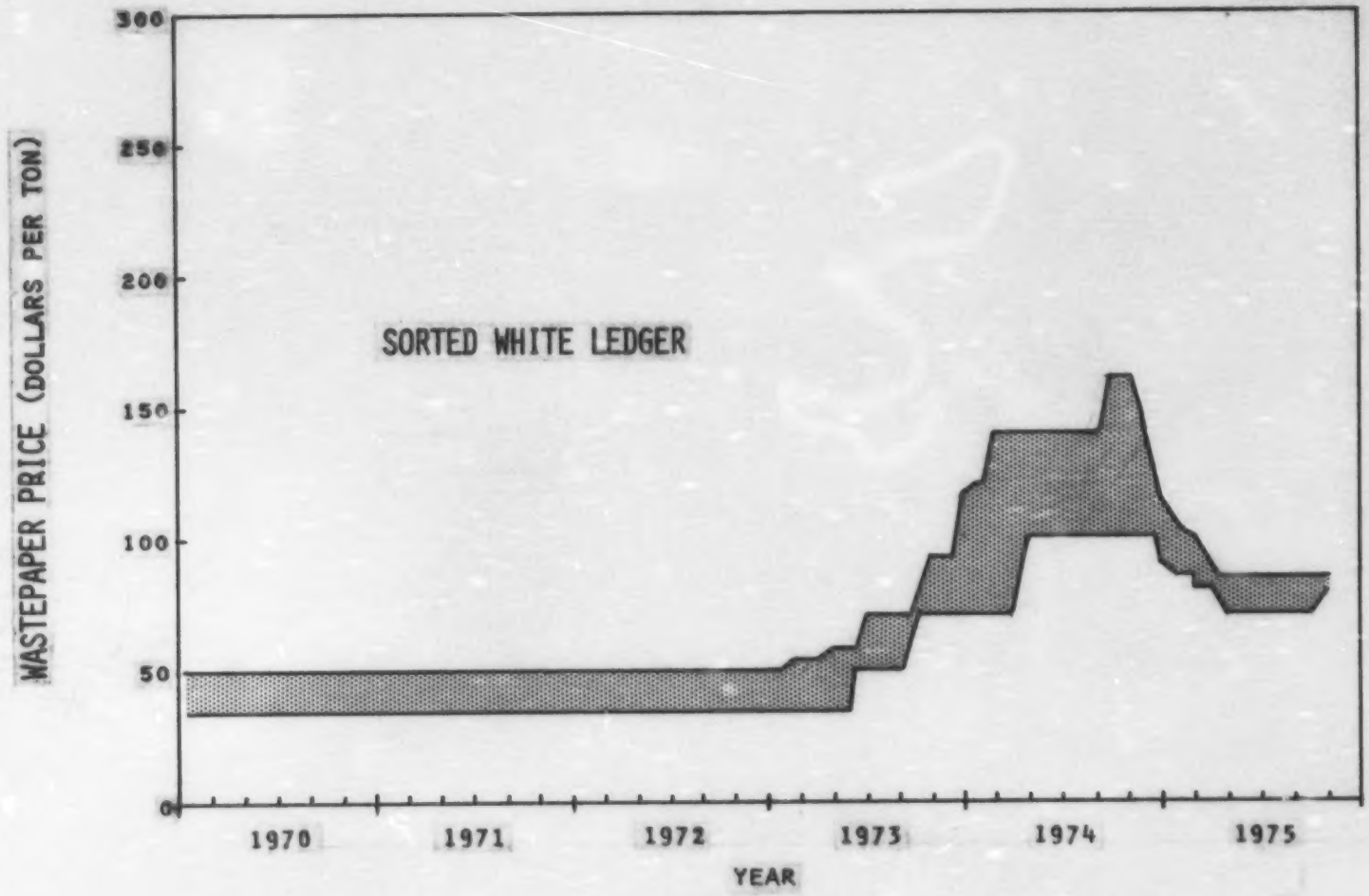

FIGURE A-2

HISTORICAL SORTED WHITE LEDGER PRICES

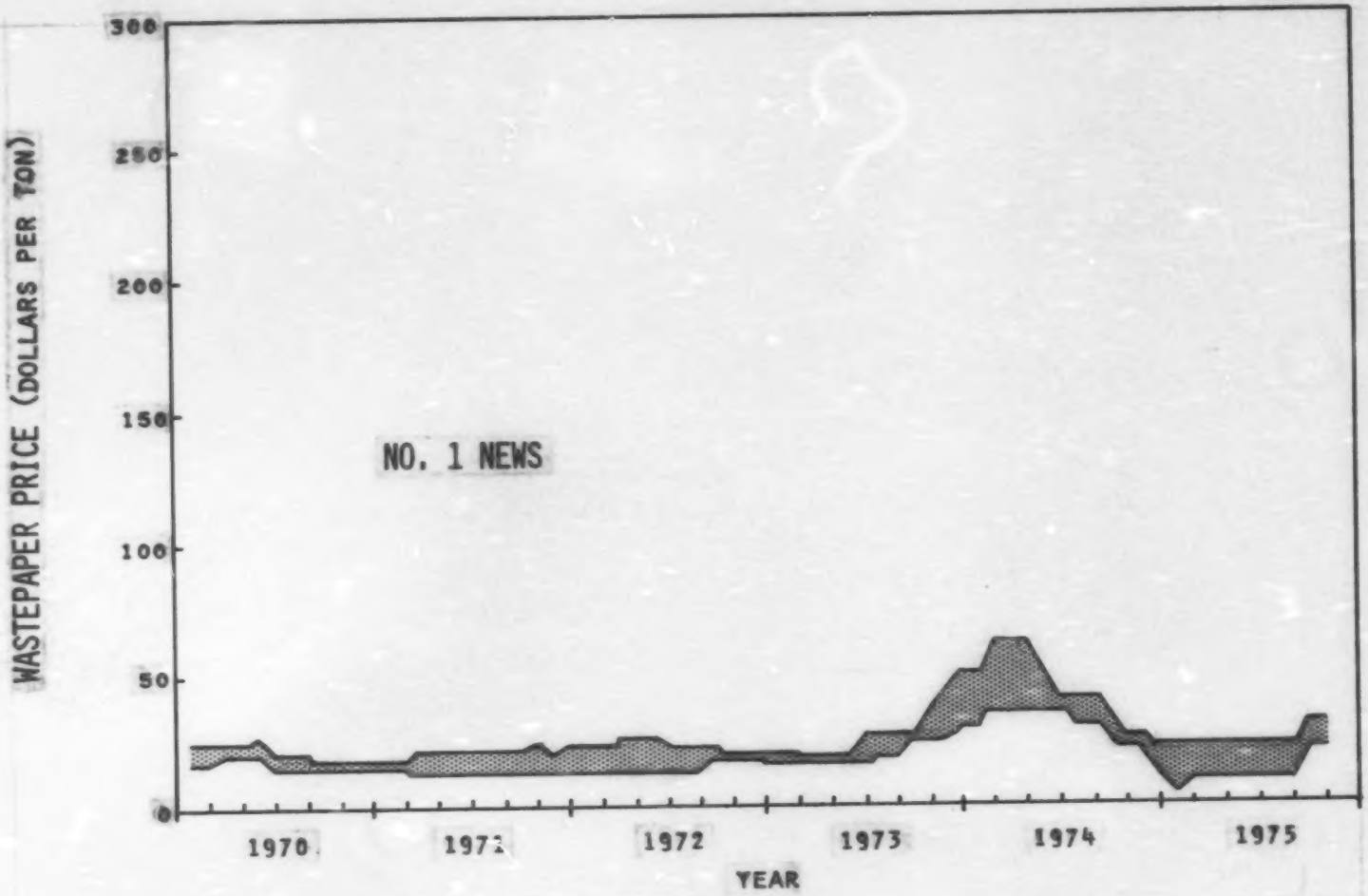

FIGURE A-3

HISTORICAL NO. 1 NEWS PRICES

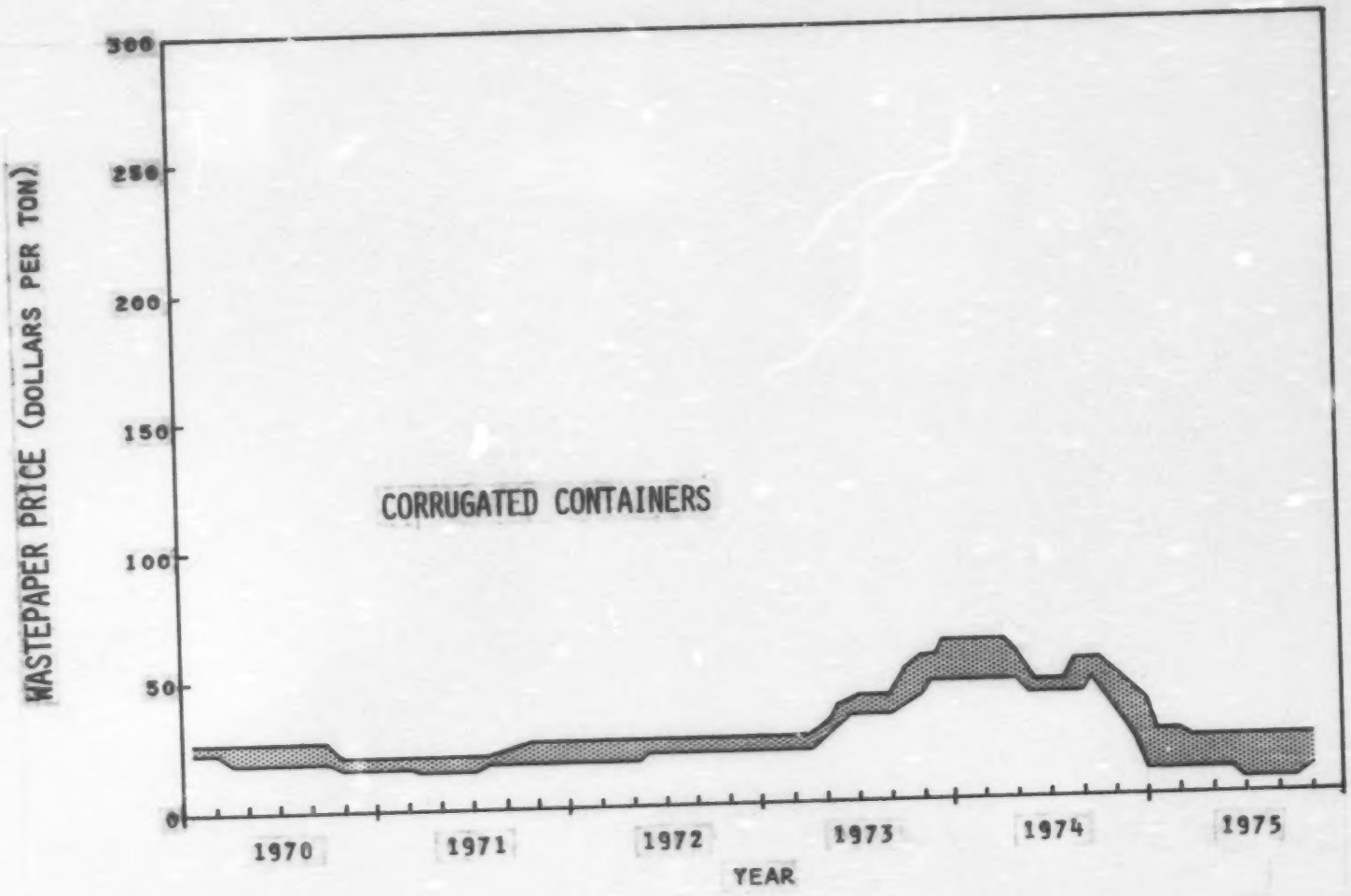

FIGURE A-4

HISTORICAL CORRUGATED CONTAINER PRICES

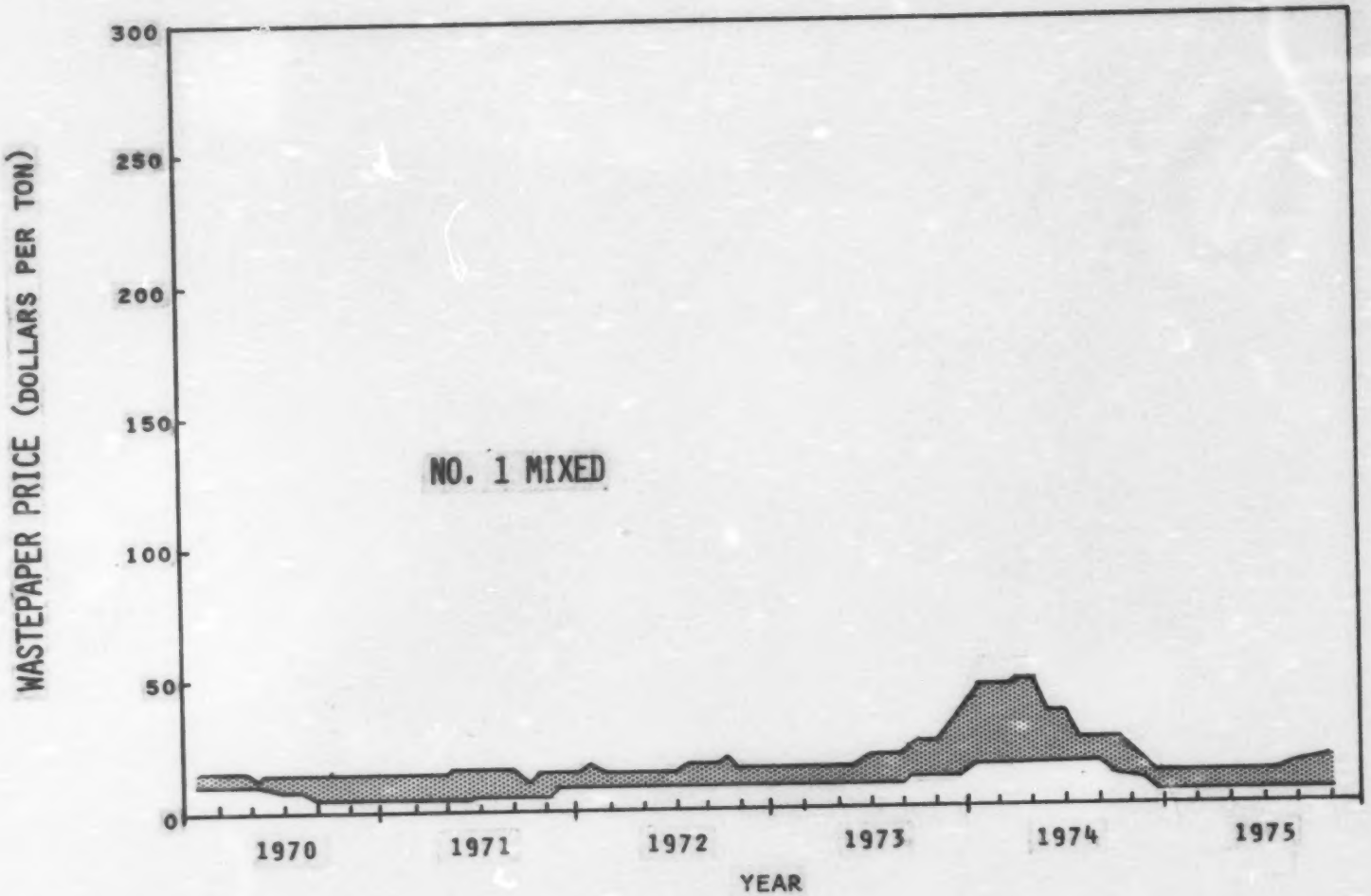

FIGURE A-5

HISTORICAL NO. 1 MIXED PRICES

APPENDIX B

COST DATA FOR OPTIMIZATION ANALYSIS

TABLE B-1

COST ANALYSIS OF ALTERNATIVE SOURCE SEPARATION APPROACHES/SCHEMES
-Hypothetical General Office Building-

Contributing Factors	Solid Waste Management Costs ($/month)						
	Prior to Source Separation	After Source Separation					
		Scheme 1			Scheme 2	Scheme 3	Scheme 4
		Desk Top	Dual Basket	Central Container	Desk Top	Desk Top	Desk Top
COSTS							
Labor							
. 18 custodians @ 1.6 hrs/day x $5/hr x 22 days/mo	3,168	3,168	3,168	3,168	3,168	3,168	3,168
. Desk top @ .1 hr/day x $5/hr x 22 days/mo	--	11	--	--	11	11	11
. Dual basket @ .9 hr/day x $5/hr x 22 days/mo	--	--	99	--	--	--	--
. Central container @ .1 hr/day x $5/hr x 22 days/mo	--	--	--	11	--	--	--
. Sorters @ 10 hrs/ton x $4/hr x 19 tons recovered	--	--	--	--	--	--	760
SUBTOTAL LABOR	3,168	3,179	3,267	3,179	3,179	3,179	4,039
Equipment							
. Prior to source separation	180	180	180	180	180	180	180
. After source separation							
Desk top	--	2	--	--	2	2	2
Dual basket	--	--	32	--	--	--	--
Central container	--	--	--	21	--	--	--
SUBTOTAL EQUIPMENT	180	182	212	201	182	182	182

Continued

TABLE B-1 (continued)

Contributing Factors	Prior to Source Separation	Solid Waste Management Costs ($/month) After Source Separation					
		Scheme 1			Scheme 2	Scheme 3	Scheme 4
		Desk Top	Dual Basket	Central Container	Desk Top	Desk Top	Desk Top
Overhead . Administration . Land . Building	Assumed @ 5% of labor and equipment costs	167	168	174	168	168	168
Disposal		810	652	682	672	630	539
TOTAL HANDLING COST		4,649	4,181	4,335	4,220	4,159	4,068
SAVINGS							
Revenue							
. Tab cards @ $100/ton Desk top/Dual/ Central @ 0.9 tpm		--	90	90	90	90	90
. Computer printout/white ledger @ $50/ton Desk @ 10.8 tpm Dual @ 8.6 tpm Central @ 9.3 tpm		--	540	430	465	--	--
. Computer printout @ $60/ton Desk @ 1.9 tpm		--	--	--	--	--	--
. Colored ledger @ $25/ton Desk @ 12.4 tpm Desk @ 1.6 tpm		--	--	--	--	310	--
. Corrugated @ $10/ton Desk @ 2.4 tpm		--	--	--	--	--	--

Continued

TABLE B-1 (continued)

Contributing Factors	Solid Waste Management Costs ($/month)						
		After Source Separation					
	Prior to Source Separation	Scheme 1			Scheme 2	Scheme 3	Scheme 4
		Desk Top	Dual Basket	Central Container	Desk Top	Desk Top	Desk Top
. Newspaper @ $10/ton Desk @ 4.4 tpm	--	--	--	--	--	--	44
. Mixed low grade @ $5/ton Desk @ 19.2 tpm	--	--	--	--	--	96	--
SUBTOTAL SAVINGS	--	630	520	555	400	186	738
NET MONTHLY SOLID WASTE MANAGEMENT COSTS	$4,649	3,570	3,815	3,665	3,759	3,882	4,233
TONS GENERATED PER MONTH	30	30	30	30	30	30	30
NET COST PER TON	155	119	127	122	125	129	141

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